AD-A096 480 HAZLETON ENVIRONMENTAL SCIENCES CORP NORTHBROOK IL F/G 6/6
GREAT RIVER ENVIRONMENTAL ACTION TEAM (GREAT II). LITERATURE RE--ETC(U)
DEC 80 DACW25-79-C-0066
UNCLASSIFIED ES-9057 NL

1 OF 6
AD A
096480

LEVEL II

GREAT II
Fish and Wildlife Management Work Group

The GREAT River

AD A096430

DTIC ELECTE MAR 17 1981 A

LITERATURE REVIEW OF SELECTED BIBLIOGRAPHIES

Great River Environmental Action Team

81 3 16 172

Report to

Fish and Wildlife Management Work Group of GREAT II

~~Rock Island, Illinois~~

(Great River Environmental Action Team

Literature Review of Fish and Wildlife
Resources Annotated Bibliography.)

U.S. Army Corps of Engineers
Rock Island District
Contract No. DACW25-79-C-0066

Hazleton ES ~~No.~~-9057

Prepared and Submitted
by
Hazleton Environmental Sciences

1 December 1980

411 12

ABSTRACT

The purpose of this report was to identify and discuss significant data voids in the literature for fish and wildlife resources, and man-induced impacts on these resources, relative to the Upper Mississippi River. After the data voids were identified, priorities were established and critical path schedules were developed for completing the work to fill the data voids. In addition, specific study related information necessary to conduct the studies to fill the data voids were provided.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

1.0 Introduction

GREAT (Great River Environmental Action Team) was established in 1974 as a funded river management study to address the Upper Mississippi River as a biological and hydrological system and to address how the many State and Federal agencies working on the river could coordinate their efforts, find solutions to the problems of the river, and implement the solutions in a cooperative manner. It is composed of representatives from the following five principle Upper Mississippi River basin states and the river resource-oriented Federal agencies:

State of Illinois
State of Iowa
State of Minnesota
State of Missouri
State of Wisconsin
U.S. Dept. of the Interior - Fish and Wildlife Service
U.S. Dept. of Agriculture - Soil Conservation Service
U.S. Dept. of Defense - Dept. of the Army - Corps of Engineers
U.S. Dept. of Transporation - U.S. Coast Guard
U.S. Environmental Protection Agency

The Upper Mississippi River is divided into three geographical regions. The GREAT I region includes that portion of the river from Lock and Dam 1 at Minneapolis, Minnesota, to Lock and Dam 10 at Guttenberg, Iowa. The GREAT II region stretches from Lock and Dam 10 to Lock and Dam 22 at Saverton, Missouri. The GREAT III region consists of the lower third of the Upper Mississippi River from Lock and Dam 22 to the confluence of the Ohio River at Cairo, Illinois.

The report contained herein was prepared for the Fish and Wildlife Management Work Group of GREAT II under contract to the U.S. Army Corps of Engineers. The report is divided into four Tasks (A-D).

The primary purpose of Tasks A and B of this report was to define significant data voids and inadequacies in the literature especially as they relate to various study plans, management plans, resource use plans, and construction and maintenance plans which have been developed for the Upper Mississippi River. Tasks A and B provide a catalog of existing information about life history requirements of fish and wildlife resources and man-induced impacts on fish and wildlife resources of the Upper Mississippi River from its headwaters to the confluence with the Ohio River at Cairo, Illinois. The information presented in this catalog was compiled primarily from abstracts of the literature as presented in: 1) the "GREAT II Fish and Wildlife Management Work Group, Annotated Bibliography, Vol. I and II"; 2) the addendum to the "Fish and Wildlife Management Work Group, Annotated Bibliography "; 3) the "GREAT II Environmental Impacts Study of Mississippi River Year-Round Navigation," Vol. II-Annotated Bibliography"; and 4) the "Effects of Navigation in Inland Waterways on the Environment and Related Water Quality Parameters; An Annotated Bibliography".[†] In addition, known

---

[†]ERT/Ecology Consultants, Inc. 1978. Effects of navigation in inland waterways on the environment and related water quality parameters; an annotated bibliography. Prepared for Upper Mississippi River Basin Commission, Main Stem Level B.

ERT/Ecology Consultants, Inc. 1979. Environmental impacts study of Mississippi River year-round navigation. Vol. II - Annotated Bibliography. Prepared for the U.S. Army Corps of Engineers, Rock Island District. Rock Island, Illinois. Contract No. DACW25-79-C-0013.

Hazleton Environmental Sciences Corp. 1979. GREAT II Fish and Wildlife Management Work Group, annotated bibliography. Vol. I and II. Prepared for U.S. Army Corps of Engineers, Rock Island District. Rock Island, Illinois. Contract No. DACW25-78-C-0002.

Hazleton Environmental Sciences Corp. 1979. GREAT II Fish and Wildlife Management Work Group, annotated bibliography. Vol. I and II. Addendum. Prepared for U.S. Army Corps of Engineers, Rock Island District. Rock Island, Illinois. Contract No. DACW25-78-C-0002.

literature not included in these four documents was also included in this discussion. It must be emphasized that the abstracts reviewed contained a varying amount of detail, and the information attainable from the abstracts was often limited. In some cases, abstracts were not available. Moreover, the annotated bibliographies contained no literature dated after May 1978. Consequently, some articles utilized in the discussion were drafts of Environmental Impact Statements which were not finalized until after May 1978; therefore this catalog contains draft information which has not been subject to public review and should be used with caution.

The primary purpose of Task C was to establish priorities and develop a critical path schedule for completing work to fill the data voids identified in Tasks A and B. This portion of the report consists of a series of tables that were developed to further identify the data voids. From the tables, a list of critical issues to be addressed and a critical path schedule to complete the work to fill the data voids were developed. The information included under this Task was developed after discussions with the Fish and Wildlife Management Work Group of GREAT II. It was originally planned that the list of critical issues and data voids would be based on specific activities which are or will be occurring on the Upper Mississippi River, such as the construction of a specific bridge at a particular site. This level of detail proved impractical and the decision was made to evaluate only general types of activities, such as the impacts on the fish and wildlife resource of building a bridge or dredging a channel.

Completing the tables for Task C required many random and subjective judgements. Most of the literature that was reviewed described various

indigenous biological communities in varying amounts of detail; however, whether the article was pertinent to channel construction, to point source discharges, or to any of the other activities was often indiscernible from the abstract. The tables therefore show more data voids than may actually exist.

The primary purpose of Task D was to provide information concerning the prioritized issues identified in Task C, as follows: the appropriate entities to address the issues; the cooperative entities; the objectives of the studies; and the estimated time and costs to complete the studies. The original objective was to provide specific information for each of the first 20 prioritized issues in Task C. Through the course of the study, it was found to be unfeasible to develop specific information for the generalized issues that were ultimately identified; therefore, only generic information has been provided.

2.0 Methods

2.1 Task A and B

The requirements of Tasks A and B were initially addressed through preparation of a detailed outline (Table 1.0). The outline was divided into two major headings: Life History Requirements of Fish and Wildlife Resources; Man-induced Impacts on Fish and Wildlife Resources. Each of the two major headings was further broken down into various subtopics where the existing information, as well as voids in the literature, were identified on an individual pool basis if possible. The first major heading was divided into Threatened and Endangered Species, and each of the other phylogenetic categories of biota including all forms of life that might be impacted by a river activity. The outline as originally prepared was not followed exactly in the course of preparing Tasks A and B due to the non-availability of some literature. Where little information existed, geographical regions and subtopics were combined in an effort to reduce redundancy in the discussion of each subtopic. Following is a further explanation of some of the categories.

Periphyton was included in the section on plankton because of the close association between phytoplankton and periphyton in a river environment. Primary production was also included with phytoplankton while protozoans were included with zooplankton. Molluscs were separated from the other benthic organisms because of the special concern for these organisms. The section General Fisheries was created to cover articles on fish not specific to sport, commercial, or forage categories. Amphibians and reptiles were combined into one category. The category on birds included only waterfowl and waterbirds; other birds were included in the category General Wildlife. Bacteria were included in the category General Water Quality since they were only discussed in terms of water quality.

Table 1.0. Topical outline for Tasks A and B.

I. Life History Requirements of Fish and Wildlife Resources

A. Rare and Endangered Species

1. Freshwater Mussels
2. Fish
3. Amphibians and Reptiles
4. Birds
5. Macrophytes
6. Other Species - Plankton

B. Plankton

1. Phytoplankton
2. Zooplankton
3. Miscellaneous Organisms - Periphyton

C. Molluscs

1. Freshwater Mussels
2. Fingernail Clams
3. Other Molluscs

D. Benthos (Excluding Mollusca)

1. Aquatic Insects
2. Miscellaneous Macroinvertebrates

E. Macrophytes

F. Fish

1. Sport Fish

a. Spawning and Reproduction
b. Age and Growth
c. Feeding Habits
d. Distribution, Movement and Abundance
e. Management Techniques
f. Parasites and Diseases

2. Commercial Fish

a. Spawning and Reproduction
b. Age and Growth
c. Feeding Habits
d. Distribution, Movement and Abundance
e. Management Techniques
f. Harvest and Gear Evaluation
g. Parasites and Diseases

Table 1.0. (continued)

3. Forage Fish

   a. Spawning and Reproduction
   b. Age and Growth
   c. Feeding Habits
   d. Distribution, Movement and Abundance
   e. Management Techniques
   f. Parasites and Diseases

4. General Fisheries

   a. Spawning and Reproduction
   b. Age and Growth
   c. Feeding Habits
   d. Distribution, Movement and Abundance
   e. Management Techniques
   f. Taxonomy
   g. Diseases and Anomolies

G. Amphibians and Reptiles

H. Birds

1. Waterfowl

   a. Nesting and Rearing
   b. Feeding
   c. Distribution and Abundance
   d. Habitat
   e. Management Techniques

2. Waterbirds

I. Mammals

J. General Wildlife

II. Man-Induced Impacts on Fish and Wildlife Resources

A. Maintenance/Construction Activities

1. Channels
2. Harbors
3. Bridges and Pipelines

B. Encroachment, Including Flood Protection

1. Industrial
2. Municipal
3. Agricultural
4. Recreational

Table 1.0. (continued)

C. Navigation

1. Commercial
2. Recreational

D. General Water Quality

E. Waste Discharge Water Quality Impacts

1. Industrial
2. Municipal
3. Agricultural
4. Recreational

F. Sedimentation/Erosion

The second major heading was divided into the types of activities which could affect the fish and wildlife of the river. They included maintenance/construction activities, encroachment, navigation, water quality, waste discharges, and sedimentation/erosion.

Each topic under each major heading was further broken down geographically into the three GREAT Regions, and the literature for each topic was discussed on a Pool basis if possible. The discussions of each topic entailed the development of corresponding tables. These tables are presented in Appendix A.

2.2 Task C

Task C was initiated by developing a list of activities which occur on rivers. Ten activities were determined: 1) channel construction and maintenance, 2) harbor, levee, and breakwall construction and maintenance, 3) corridor construction and maintenance, 4) wingdam construction and maintenance, 5) point source intakes and discharges, 6) non point source discharges, 7) mitigation, 8) encroachment, 9) commercial navigation, and 10) recreational navigation. Activities having common types of impacts were categorized together to avoid repetition. Detailed definitions of the above ten categories are provided in Section 4.0.

Next, a topical list of important parameters was prepared which consisted of threatened and endangered species, each of the indigenous biological communities inhabiting a river environment, habitat alteration parameters, and water quality alteration parameters. Detailed definitions of the latter two sets of parameters are also provided in Section 4.0. Matrix tables were then developed based on the topical list (threatened and endangered species and indigenous biological communities versus the habitat

and water quality alterations). Six geographical regions were determined to be of significant interest, and a table for each activity was developed per region. The geographical regions were: 1) GREAT I; 2) Pool 4 (which is also part of GREAT I); 3) GREAT II; 4) Pool 19 (which is also part of GREAT II); 5) GREAT III; and 6) the Middle River (which is also part of GREAT III). Pools 4 and 19 were singled out because of the large migrating waterfowl populations which utilize these areas. The Middle River was singled out because it is ecologically different from the rest of the Upper Mississippi River in that it is not separated into Pools.

Finally, the numbers in the body of the tables represent a numerical categorization of the data available for each activity and for each of the six geographical regions. The numerical scheme is defined as follows:

0 = no data available
1 = little data available
2 = average amount of data, old (pre 1965)
3 = average amount of data, recent
4 = an abundance of data, old (pre 1965)
5 = an abundance of recent data
* = category does not apply.

The year 1965 was chosen as the date for distinguishing between older and recent data because more frequent and greater flooding has occurred since the flood of 1965, and this has possibly affected the ecology of the river.

To supplement the data available from Tasks A and B, telephone contacts were made to personnel in various agencies and organizations, as well as other persons who have an interest in the ecology of the Upper Mississippi River.

After the tables were completed, the voids in the literature for various parameters were evident. From the tables, a list of prioritized critical issues which should be addressed, and three critical path

schedules (one for each GREAT region) were prepared. The Task C tables are provided in Appendix B.

The critical path schedules were prepared by plotting each specific study to be conducted to fill the data voids on a graph with time along the horizontal axis. Each study is represented by a single horizontal solid line, the length of which is a relative estimate of the amount of time needed to complete the study. In the case of fish egg and larval studies, there are two parts of the study to be conducted at different times; since they are related, they are connected by a horizontal broken line. Vertical lines connecting studies indicate that the studies are related and may be conducted concurrently.

2.3 Task D

Task D was accomplished by providing general information about the studies identified in Task C that will be required to fill the data voids. The information provided was: 1) the appropriate entity to address the studies; 2) the cooperative entities; 3) the objectives of the studies; and 4) the estimated time and cost to complete the studies. Only generic-type information was developed for this task because of the generalized nature of the studies identified in Task C.

It is reemphasized that because of the limited information that was attainable from the abstracts reviewed for this study, the results should be used only as a guideline; future studies should not be initiated without first verifying the literature. This is especially true relative to the May 1978 cut-off date of the original bibliographies, and studies that may be ongoing which are not addressed in this report.

3.0 Tasks A and B

3.1 Life History Requirements of Fish and Wildlife Resources

A. Rare and Endangered Species

1. Freshwater Mussels

a. GREAT I

For this discussion of rare and endangered freshwater mussels, all three GREAT Regions will be combined.

Information: Twenty-five articles and reports dealing with federal and state rare and endangered freshwater mussel species were compiled and reviewed (Tables 1-3). The information from these references was spread fairly evenly among the pools of the Upper Mississippi River. Pool 15 of the GREAT II Region was referenced most often. Most articles provided pool specific data.

Voids: The two federally endangered mussel species, Lampsilis higginsii and Potamilus capax, found in the Upper Mississippi River have always been uncommon and rarely collected. Therefore information concerning the life history, physiology, ecological preferences and taxonomy of these species, (especially P. capax) is scarce.

Evaluation: The federal list of endangered and threatened species classified L. higginsii, the "Higgins' Eye", and Potamilus (= Proptera) capax, the "Fat Pocketbook", as endangered species (U. S. Department of the Interior 1976). Of all the freshwater mussels on the list, only these two species had ranges which included the Upper Mississippi River. Another Mississippi River mussel, Cumberlandia monodonta (the "Spectacle Case"), was reviewed for consideration as a federally endangered species.

Many mussel surveys of the Upper Mississippi River have been conducted because of the concern for these endangered species. The most

intensive of these surveys involved U.S Army Corps of Engineer dredge sites which were surveyed for mussels by Fuller (1978, 1980, in progress) in the GREAT I and II reaches, Frietag (1978) in the GREAT II region, and Brice and Lewis (1980, in progress) in the GREAT II and III areas. Several other localized surveys have been conducted in Pool 8 (Havlik 1977), Pool 12 (Cawley 1977, 1978) and Pool 15 (Ecology Consultants, Inc. 1977) to determine the potential negative impact of dredging operations, gravel mining and bridge construction on endangered mussel species. At the Pool 15 site, the endangered species L. higginsii was discovered at the future bridge site. Specimens of L. higginsii and C. monodonta, as well as other mussels, were removed from the dredge piling sites and the L. higginsii were transplanted to other suitable areas (NUS Corporation 1979, Oblad 1980, in progress).

Additional site-specific data concerning these federal endangered mussel species were obtained from recent surveys by van der Schalie and Bates (1976) in Pool 17; Wapora, Inc. (1977) in Pool 17; Havlik and Stansbery (1977) in Pool 10; Lewis and Brice (1977) and Lewis (1979) in Pool 14; Havlik (1978) in Pools 7 and 8; Perry (1979) in Pools 9 - 26; and Mathiak (1979) in Pool 10. Recent discoveries of the listed and reviewed endangered species in the Upper Mississippi River were summarized by Nelson and Frietag (1979). Older surveys and lists of mussels of the Upper Mississippi River, which are reviewed in the freshwater mussel section of this report, provide excellent historical information concerning the distribution of these endangered species.

Missouri has the only state list of rare and endangered species which includes freshwater mussels other than the federal endangered species. Eleven species which probably now occur in the Upper Mississippi

River are listed by Missouri as rare or endangered (Nordstrom et al. 1977). Of these species, Potamilus capax and P. purpuratus have been recently reported only from the Missouri reach of the Mississippi River (Perry,1979). The remaining species are more commonly collected in the richer mussel fauna in the Mississippi River north of Missouri. These species are listed in many studies discussed in the freshwater mussel section of this report.

Recommendations: The lack of modern information concerning the federally endangered species, Potamilus capax, and the reviewed species, Cumberlandia monodonta, is probably due to the lack of sampling effort in the habitats preferred by these species. Intensive sampling of the rock-cobble substrates in the GREAT II reach for C. monodonta and the backwater areas of the lower GREAT II and upper GREAT III areas for P. capax would provide additional data regarding the actual distribution and abundances of these species.

The effect of the pearl button industry on endangered species needs to be researched. The use of the brail and mussel dredge in areas where endangered species occur can be fatal to these species, and in the case of the dredge the habitat can be destroyed. Mussel fishing in areas with known concentrations of endangered species should be restricted to hand picking only.

A recovery program for federally endangered species should be initiated to restore the depleted numbers. Sufficient life history information is probably present for Lampsilis higginsii to begin the program, however, additional research of P. capax and C. monodonta life histories would be required. Similar programs could be utilized for other rare or uncommon Mississippi River mussel species.

The endangered mussel populations of the Upper Mississippi River need to be reviewed and researched to determine their actual population status. If a species is found to have a declining, non-reproducing population, the reason for the decreasing numbers should be determined. Potential problems such as increased navigation, the lock and dam system, chemical pollutants, non-point source pollutants or poorer water quality should be considered.

All states bordering the Upper Mississippi River should prepare detailed accounts of the rare and endangered mussel species occurring in their respective reaches of the river. This information could be utilized to protect these rare species in each state and summarized to determine the health of the listed species in the entire Upper Mississippi River.

Literature Cited:

Brice, J. R. and R. B. Lewis. 1980, in progress. A survey of selected dredge sites for the presence of freshwater mussels within the Rock Island District of the U. S. Army Corps of Engineers. Prepared by Hazleton Environmental Sciences, Inc.

Cawley, E. T. 1977. Study of the environmental impacts of dredging by the Dubuque Sand and Gravel Company in Pool 12 of the Upper Mississippi River. Dubuque, IA. 7 pp.

__________. 1978. Preliminary report on clam survey on Dubuque bridge site. Environ. Res. Cen., Loras College. Dubuque, IA. 8 pp.

Ecology Consultants, Inc. 1977. Sylvan slough mussel study for new Moline bridge at Rock Island Arsenal, Illinois. Rept. to U. S. Army Corps of Engineers, Omaha Dist. 12 pp.

Freitag, T. M. 1978. A survey of selected dredge sited for the presence of fresh water mussels within the Rock Island Dist.. Rock Island District, U. S. Army Corps of Engineers, Operations Division. 7 p. + appendices.

Fuller, S. L. H. 1978. Freshwater mussels (Mollusca: Bivalvia: Unionidae) of the Upper Mississippi River: Observations at selected sites within the 9-foot channel navigation project on behalf of the United States Army Corps of Engineers. Academy of Natural Sciences of Philadelphia. Philadelphia, PA. 401 pp.

________. 1980, in progress. Freshwater mussels (Mollusca: Bivalvia: Unionidae) of the Upper Mississippi River: Observations at selected sites within the 9-foot channel navigation project on behalf of the United States Army Corps of Engineers. Academy of Natural Sciences of Philadelphia, Philadelphia, PA.

Havlik, M. E. 1977. A Naiad Mollusk Survey of the Mississippi River Adjacent to Isle La Plume at LaCrosse, WI. Contr. with City of LaCrosse, WI. Unpubl. Rept.

________. 1978. Naiad mollusks of the Mississippi River near LaCrosse, Wisconsin. Mississippi River Reasearch Consortium, 11th Annual Meeting, June 8-10. LaCrosse, WI.

Havlik, M. E. and D. H. Stansbery. 1977. The naiad mollusks of the Mississippi River in the vicinity of Prairie du Chien, WI. Ann. Rept. Am. Malacological Union.

Lewis, R. B. 1979. Benthic macroinvertebrate study. In: C. A. Altstaetter ed. Environmental monitoring in the Mississippi River near Quad-Cities Station (1968-1978). NALCO Environ. Sci. Rept. to Comm. Ed. Co., Chicago. pp. 6.1-1.148 + appendix.

Lewis, R. B., and J. R. Brice. 1977. Freshwater mussel survey. In: R. M. Gerhold, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (Feb. 1976-Jan. 1977). NALCO Environ. Sci. Rept. to Comm. Ed. Co., Chicago. pp. 535-554.

Mathiak, H. A. 1979. A river survey of the unionid mussels of Wisconsin 1973-1977. Sand Shell Press, Horicon, WI. 75 pp.

Nelson, D. A. and T. M. Freitag. 1979. Ecology, identification, and recent discoveries of Higgin's Eye, Spectacle Case, and Fat Pocketbook. in T. L. Rasmussen (ed.). In Press. Proceedings of the UMRCC Symposium on Upper Mississippi River bivalve mollusks.

Nordstrom, G. R., W. L. Pflieger, K. C. Sadler, and W. H. Lewis. 1977. Rare and endangered species of Missouri. Missouri Dept. Cons. and U. S. Dept. Agr. Soil Cons. Service. 129 pp.

NUS Corporation. 1979. The naiads (Mollusca) of Sylvan Slough, Mississippi River near Moline, Illinois; an experiment in naiad relocation. Draft Contract Report DACA45-78-M-0368, Omaha District Corps of Engineers. 11 pp.

Oblad, B. R. 1980, in progress. Transplanting special status naiads from a proposed bridge construction site. in T. L. Rasmussen (ed.) Proceedings of the UMRCC Symposium on Upper Mississippi River bivalve mollusks.

Perry, E. W. 1979. A survey of Upper Mississippi River mussels. In: Rasmussen, J. L., editor. A compendium of fishery information on the Upper Mississippi River. Second Edition. Upper Mississippi River Conservation Commission, Rock Island, IL. pp. 118-139.

van der Schalie, H. and J. Bates. 1976. A survey of fresh-water mussels near a proposed power plant site. Conducted for Iowa-Illinois Gas and Electric Company, Davenport, IA.

Wapora, Inc. 1977. A survey of the freshwater mussels in Pool 17 of the Mississippi River near Muscatine, Iowa. Prepared by Wapora, Inc. for Iowa-Illinois Gas and Electric Co., Davenport, IA. 37 p. + appendices.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

2. Fish

a. GREAT I

For the discussion of rare and endangered fish, all three GREAT Regions have been combined.

Information: Twenty-five references were compiled and reviewed that dealt with rare and endangered species in the Upper Mississippi River area (Tables 1-3). Of these, 20 are federal and state government lists of species given special status designation. Some of the state lists include general discussions on the geographical distribution within their jurisdictional boundaries, as well as information on habitat requirements and recommended measures for protecting the species. The remaining five references deal with a review of the state lists and a state endangered species program.

Voids: A listing of endangered and threatened species is available for the entire Upper Mississippi River; however, only general information is provided describing the distribution of these species in the river. No information was found that associated the distribution of species within specific pools of the river. Information on life history requirements was generally limited to descriptions of the habitats in which the species have been found.

Evaluation: A review of published information on Mississippi River fish species given special status designation by each of the five UMRCC states is provided by Rasmussen (1979). A total of 39 species is listed under five status categories for the entire Upper Mississippi River, of which 27 are either endangered or threatened. The number has recently increased to 30 as a result of Wisconsin's revised 1979 endangered and threatened species list. The greatest number of species listed as

threatened and/or endangered occur within the jurisdictional boundaries of Wisconsin and Iowa (17 in each state).

The species given special status designation are reported by Moyle (1975) for Minnesota; Hine et al. (1973) and Wisconsin Department of Natural Resources (1979) for Wisconsin; Roosa (1977) for Iowa; Ackerman (1975) and the Illinois Department of Conservation (1978) for Illinois; and Nordstrom et al. (1977) for Missouri. Most of these lists include a general description and maps of the distribution of each species and their habitat preference. At the present time no Upper Mississippi River fish species are included on the federal list of endangered and threatened species (U. S. Fish and Wildlife Service 1978).

An endangered species program was developed by the state of Wisconsin to better protect its endemic species (U. S. Department of the Interior 1979). The program was created shortly after passage of the state's Endangered Species Act in 1972. The intent was to gain a better understanding of the state and distribution of endangered and non-game species to restore, preserve and manage habitat to benefit endemic species, and to reintroduce declining or extirpated native species to the state. A complete revision of Wisconsin's list of endangered and threatened species was made in 1979 as a result of studies associated with the program.

Recommendatons: Special status species lists have been compiled for each of the five states bordering the Upper Mississippi River region; however, there is inconsistency regarding the type and number of categories used and their definitions among the five states. Establishment of standard categories and definitions for each category should be made for the entire Upper Mississippi River region.

No comprehensive study of the endangered and threatened fish for the entire Upper Mississippi River region has been conducted to date. A coordinated effort should be made among the five states to identify specific areas where life history information on these species is lacking or inadequate. Detailed studies could then be implemented to acquire the needed information. A reevaluation of the status and distribution of fish species in the river could then be made based on the findings from these studies and existing information.

A program for the protection and management of endemic species in the river, such as the Endangered Species program established by the state of Wisconsin, should be initiated by all states bordering the Upper Mississippi River so that appropriate measures can be taken to help guard against further declines in the populations of these species.

Literature Cited:

Ackerman, K. 1975. Rare and endangered vertebrates of Illinois. Bureau of Environmental Sciences, Illinois Department of Transportation. 50 pp.

Hine, R. L. et al. 1973. Endangered animals in Wisconsin with supplementary lists of animals with changing status - extirpated animals - uncommon plants and plant communities. Wis. Dept. Nat. Res., Madison. 29 pp.

Illinois Department of Conservation. 1978. Endangered and threatened wildlife. Spec. brochure.

Moyle, J. B. 1975. The uncommon ones - animals and plants which merit special consideration and management. Minn. Dept. Nat. Res. Spec. Pub. 32 pp.

Nordstrom, G. R., W. L. Pflieger, K. C. Sadler, and W. H. Lewis. 1977. Rare and endangered species of Missouri. Mo. Dept. Conserv. and US Dept. Agr. Soil Cons. Serv. 129 pp.

Rasmussen, J. L. 1979. A compendium of fishery information on the Upper Mississippi River. UMRCC Spec. Pub. 259 pp.

Roosa, D. M. 1977. Endangered and threatened fish of Iowa. Spec. Rept. of the Preserves Bd. No. 1, Des Moines, Ia. 25 pp.

U. S. Department of the Interior. 1979. Wisconsin ups its protection of native animals and plants. In Endangered species technical bulletin Vol.IV (1):7-12.

U. S. Fish and Wildlife Service. 1978. Great Lakes "Red Book" for threatened and endangered species. USDI, FWS, Reg. III.

Wisconsin Department of Natural Resources. 1979. Wisconsin endangered and threatened species lists pursuant to Administrative Code Revision (NR 27) effective October 1, 1979. Office of Endangered and Nongame Species, Wis. Dept. of Nat. Resources, Madison. 3 pp.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

3. Amphibians and Reptiles

a. GREAT I

In this discussion of rare and endangered amphibians and reptiles, all regions of the Upper Mississippi River have been combined.

Information: At the present time the United States Fish and Wildlife Service, Department of the Interior List of Endangered and Threatened Wildlife and Plants does not include any amphibians or reptiles found in the Upper Mississippi River area. The Missouri Dept. of Conservation and Minnesota Dept. of Natural Resources, however, have each compiled a list of amphibian and reptile species which merit varying degrees of special consideration and management (Table 1-3).

Voids: Although state governments have compiled lists of rare and endangered species no work has been found that associates these species with specific Mississippi River pools.

Evaluation: Moyle (1975) reported on the amphibians and reptiles that Minnesota considers to be endangered or threatened. The list identifies four turtles, one snake, one frog, a newt, a salamander, and two lizards which deserve special protection in that state. Preservation of suitable habitat for these species will ensure their survival in Minnesota. Specific distributions of each of the species is not provided.

Rare and endangered species of Missouri are described by Nordstrom et al. (1977). This is a very good publication which contains a list of species with annotations describing the status, distribution, and the broad ecological community in which each species is normally found. This book is a major revision of the bulletin which was first published in 1974. The authors hope that by publishing this information, programs of research,

preservation and management can be initiated to restore and preserve needed habitats.

Recommendations: It is recommended that before any impact activities in specific pools are undertaken these lists should be consulted to prevent damaging potential habitats of these rare species.

Literature Cited:

Moyle, J. B. 1975. The uncommon ones - animals and plants which merit special consideration and management. Minn. Dept. Nat. Res. Spec. Pub. 32 pp.

Nordstrom, G. R., W. L. Pflieger, K. C. Sadler, and W. H. Lewis. 1977. Rare and endangered species of Missouri. Mo. Dept. Conserv. and US Dept. Agr. Soil Cons. Serv. 129 pp.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

4. Birds

a. GREAT I

The discussion of rare and endangered birds for all three GREAT Regions have been combined.

Information: Eighty-four articles and publications referring to endangered wildlife species in the Upper Mississippi River region were compiled (Tables 1-3). Of these, 70 exclusively discuss the Bald Eagle which utilizes the river environment during migration and winter. The majority of papers involving the Bald Eagle are surveys of populations or notes on sitings of individual birds. Other, more general papers discuss habitat requirements and feeding activities divided by state or general river area since populations are generally too scattered and mobile to allow for site specific studies.

Information concerning other endangered wildlife species is found in 14 publications. The articles are primarily lists, by state or region, of endangered and threatened animals. Each usually includes a general discussion of the species' distribution and habitat requirements.

Voids: Although information concerning endangered species is available for the entire Upper Mississippi River region, it is quite general in terms of locations of specific populations as well as species' food and habitat requirements. Only a few site-specific studies are available. These are biased toward the Bald Eagle and are usually limited to population counts during the winter.

Evaluation: Bald Eagle: The most comprehensive study of winter Bald Eagle populations on the Upper Mississippi River has been conducted by Fawks (1960-1977). This series of censuses covers the period from 1960 to 1976 and examines trends in the distribution and abundance of

the species. Detailed studies of local populations were made by Jonen (1973) in west-central Illinois and Southern (1963) in northwestern Illinois. Both authors report on behavior, habitat use and feeding of the wintering birds.

Other endangered species: Information regarding endangered bird and mammal species is available from individual state summaries (Mo. Dept. Cons. 1974, George 1971, Minn. DNR 1975). These summaries discuss each species, the reasons for their endangered status, general behavior, and food and habitat requirements. Site-specific data on the presence of individual species may be found in environmental impact studies such as those done by the U.S. Army Corps of Engineers for the East Moline, Illinois flood protection system (1974), the Rock Island, Illinois, local protection project (1974), and the Clinton, Iowa, local flood protection project (1974). These studies assess species presence as well as locations of important habitats.

Recommendations: No comprehensive study of endangered species in the Upper Mississippi River region has been completed to date. Information regarding distribution, critical habitat, behavior, food reouirements, and significant predators could be compiled through detailed examination of the scientific literature and communication with local or regional experts. A study of this type would assist in identifying specific areas of concern that might require further examination through field studies. Because the Bald Eagle has been the focus of numerous studies in the past and will probably continue to be the focus of significant scientific research effort in the future, additional studies will be necessary only in locations where a specific action may influence local populations.

Literature Cited:

Fawks, E. 1960a. Bald eagle study. Pass. Pigeon. 22(2):30-31.

__________. 1960b. Bald eagle winter survey. Audubon Bull. (1159:2-3.

__________. 1960c. A survey of wintering bald eagles. Iowa Bird Life. 30:56-58.

__________. 1960d. A January bald eagle count. Audubon Bull. (113):6-7.

__________. 1961a. A survey of wintering bald eagles: 1960-1961. Iowa Bird Life. 31(3):54-60.

__________. 1961b. Final report - February 19, 1961, bald eagle count. Audubon Bull.(119):21-22.

__________. 1962. Bald eagle survey comparison winter 1960-1961 and 1961-1962. Iowa Bird Life 32(311).

__________. 1964. Bald eagle count, February 15 or 16, 1964. Iowa Bird Life. 34(2):51.

__________. 1965. One day bald eagle count, February 13 or 14, 1965. Iowa Bird Life. 35(2):56.

__________. 1966a. Field notes - June 1966. Audubon Bull. (138):6-8.

__________. 1966b. Winter birding along the Mississippi. Audubon Bull. (1490:32-34.

__________. 1966c. One day bald eagle count on the Mississippi River - February 19 or 20, 1966. Iowa. 36:52-53.

__________. 1966d. Comparison between two bald eagle counts. Audubon Bull. (138):22-23.

__________. 1967a. One day eagle count, February 18 or 19, 1976. Iowa Bird Life. 37(2):53.

__________. 1967b. Surveyors sight nearly 650 eagles in one-day winter count in state. Audubon Bull.

__________. 1968a. One day eagle count, February 17 or 18, 1968. Iowa Bird Life. (38):92-93.

__________. 1968b. Field notes. Audubon Bull. (146):17-29.

__________. 1968c. Field notes. Audubon Bull. (145):14-16.

__________. 1969a. One day eagle count, February 15 or 16, 1969. Audubon Bull. (150):26-27.

__________. 1969b. One day eagle count, February 15 or 16, 1969. Iowa Bird Life. 39:46.

__________. 1969c. Field Notes. Audubon Bull. (151):15-16

__________. 1970a. One day eagle count, February 21 or 22, 1970. Iowa Bird Life. 40:52

__________. 1970b. One day eagle count, February 21 or 22, 1970. Audubon Bull. (154):17.

__________. 1971a. One day eagle count February 21 or 22, 1971. Audubon Bull. (158):26-27

__________. 1971b. One day eagle count - February 20 or 21, 1971. Bluebird. 38(2):2.

__________. 1972a. One day eagle count, February 29 or 20, 1972. Iowa Bird Life. 42:48-49

__________. 1972b. One day eagle count: February 29 or 20, 1972. Audubon Bull. (162):21,38

__________. 1972c. Field notes. Audubon Bull. (161):33-35.

__________. 1972d. Eagles and hawks. Audubon Bull. (161):36.

__________. 1973a. Field notes. Audubon Bull. (164):38-43.

__________. 1973b. One day bald eagle count, February 17 or 18, 1973. Iowa Bird Life. 43:49.

__________. 1974a. Results: the one-day bald eagle count. Ill. Aud. Bull. (169):15.

__________. 1974b. High counts of bald eagles - winter 1973-74. Ill. Aud. Bull. (171):13.

__________. 1974c. One day bald eagle count, February 16, 1974. Iowa Bird Life. 44(2):49-50.

__________. 1974d. Wintering eagles. <u>In</u>: Our Eagle's Future Proc. of Bald Eagle Days, Feb. 8, 9, 10, 1974. Ingram, T. N. (ed.) Eagle Valley Environmentalists, Inc. Apple River.

__________. 1975a. Other roosting lands along the Mississippi River. <u>In</u>: Bald Eagle Land: Preservation and Acquisition. Proc. of Bald Eagle Days, Jan. 31-Feb.2, 1975, Eagle Valley Environmentalists, Inc. Apple River, IL p. 21-22.

__________. 1975b. One day eagle count - February 8, 1975. Ill. Aud. Bull. (173):14-15.

__________. 1975c. One day bald eagle count - February 8, 1975. Ill. Aud. Bull. (173):14-15.

__________. 1975c. One day bald eagle count - February 8, 1975. Iowa Bird Life. 45(June):1

__________. 1976a. Wintering eagles and roosting areas. In: Save the Eagle in '76. Proc. of Bald Eagle. Ingram, T.N. (ed.). Eagle Valley Environmentalists Inc. Apple River, Ill.

__________. 1976b. One day bald eagle count - February 14, 1976. Ill. Aud. Bull. No. 177. 1 p.

__________. 1976c. Bald eagle days, Madison, Wisconsin, Jan. 30,31, and Feb. 1, 1976. (Unpublished).

__________. 1977. Bald eagle days, Jan. 28-30, 1977; Winter trends and dispersals (Unpublished).

George, W. G. 1971. Vanished and endangered birds of Illinois; a new 'black list' and 'red list'. Audubon Bull. 158:2-11.

Jonen, J. R. 1973. The winter ecology of the bald eagle in west-central Illinois. M.S. Thesis. Western Illinois Univ., Macomb, IL. 84 pp.

Minn. Dept. of Natural Resources. 1975. Animals and plants which merit special consideration and management. The uncommon ones. Minn. Dept. Nat. Res. 32 pp.

Missouri Dept. of Conservation. 1974. Rare and endangered species of Missouri. Mo. Dept. Cons. U.S.D.A. Soil Conserv. Serv.

Southern, W. E. 1963. Winter Populations, behavior, and seasonal dispersal of bald eagles in northwestern Illinois. Wilson Bull. 75:42-55.

U.S. Army Corps of Engineers. 1974a. East Moline, Illinois Flood Protection System. Draft Environmental Statement.

__________. 1974b. Clinton, Iowa Local protection project. Final Environmental Statement.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

5. Macrophytes

a. GREAT I

For the discussion of rare and endangered macrophytes, all three GREAT Regions will be combined.

Information: Inventories of rare and endangered species of plants have been compiled by the federal government (U.S. Dept. of the Interior 1976) and by the states of Illinois (Illinois Dept. of Conservation 1976), Missouri (Nordstrom et al. 1977) and Wisconsin (Wisconsin Dept. of Natural Resources 1979). These lists, however, provide little site-specific information relevant to the Upper Mississippi River. Only four papers were compiled in reference to the site specific occurrence of rare or endangered macrophytes along the Upper Mississippi River. Each of these articles addresses the presence of rare and endangered species in the GREAT III Region (Tables 1-3).

Voids: Information on the occurrence of rare and endangered macrophytes is virtually nonexistant for the GREAT I and II Region. The GREAT III Region has received some detailed attention, but nonetheless, still requires extensive research regarding the occurrence and status of rare and endangered floral species.

Evaluation: Studies by Terpening et al. (1975) Evans (1975) and Daley (1977) provide information on rare and endangered species in the GREAT III Region. Data presented by Terpening et al. (1975) were derived from the same research project. The study entailed a survey of unprotected floodplains. They reported nine vegetation cover types comprising a total of 302 species. Thirteen percent of the species examined were considered rare, uncommon or endangered in the Illinois and Missouri flora. Daley (1977) identified principal biological concerns, including rare and endangered species, along the Mississippi River from Saverton, Missouri to Cairo, Illinois.

Recommendations: The apparent paucity of data on the occurrence and status of rare and endangered floral species necessitates the implementation of in-depth survey type activities particularly in the GREAT I and II Regions. Surveys, such as the work reported for GREAT III by Terpening et al. (1974,1975) and Evans (1975), should be conducted on the upper reaches as a first step in understanding the status of rare and endangered macrophytes and also a basis for identifying future research needs.

Literature Cited:

Daley, R. H. 1977. Biological issues and concerns on the Mississippi River mainstem, from Cairo, Illinois to Saverton, Missouri. Missouri Botanical Gardens, St. Louis. 61 pp.

Evans, D. K. 1975. Characteristics of flora succession in the Middle Mississippi River Floodplain. Proc. W. Va. Acad. Sci. 47(1):7-13.

Illinois Department of Conservation. 1976. Endangered, vulnerable, rare and extirpated vascular plants in Illinois. Illinois Nature Preserves Commission. P1-10 + Add 1. (mimeo)

Nordstrom, G. R., W. L. Pflieger, K. C. Sadler, and W. H. Lewis. 1977. Rare and endangered species of Missouri. Missouri Dept. Cons. and U.S. Dept. Agr. Soil. Cons. Service. 129 p.

Terpening, V. A., J. R. Nawrot, M. J. Sweet, and D. L. Damrau. 1975. Environmental inventory and assessment of Navigation pools 24, 25 and 26, Upper Mississippi and Lower Illinois Rivers; floodplain animals and their habitats. Southern Illinois Univ., Carbondale Cooperative Wildlife Research Lab. Army Engineer Waterways Experiment Station, Vicksburg, MS. 285 p.

U.S. Department of the Interior. 1976. Endangered and threatened wildlife and plants. Fed. Reg. 41:47108-47198.

Wisconsin Department of Natural Resources. 1979. Wisconsin endangered and threatened species lists. Office of Endangered and Nongame Species. 3 pp. (Mimeo).

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

6. Other Species - Plankton

a. GREAT I

For this topic of discussion GREAT I, II and III regions will be combined.

Information: None.

Voids: No published or unpublished articles on rare and endangered zooplankton, phytoplankton, or periphyton were found for the Upper Mississippi River area. The United States Fish and Wildlife Service, Department of the Interior List of Endangered and Threatened Wildlife and Plants does not include any plankton species.

Evaluation: None.

Recommendations: None.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

B. Plankton

1. Phytoplankton

a. GREAT I

For the topic of phytoplankton all GREAT Regions will be discussed together.

Information: A total of 63 references relating to phytoplankton or primary production of the Upper Mississippi River were evaluated (Tables 4-6). Most of the work was conducted in specific pools, especially Pool 14 of the GREAT II Region near the Quad-Cities Generating Station. Biological investigations were conducted in this area to assess river conditions prior to and during station operation. Other than Pool 14 most studies have been centered in Pools 1-6 of the GREAT I Region. Little information is available on phytoplankton populations downstream of Pool 14. Some of the studies conducted for college theses are not extensive studies. In most cases sampling periods were short.

Voids: No information on phytoplankton was found for Pools 7-11, 13, 15-18 and 21-26 (Tables 4-6).

Evaluation: In the GREAT I area studies by Ernest (1967), Zeis (1970), Torborg (1970), and Lafosse (1970) were used to analyze the production rate and populations of phytoplankton species from Pool 6. The sampling was conducted during two six-day periods from which limited conclusions were drawn. A survey of the Mississippi River from Minneapolis to Winona was undertaken by Reinhard (1930) to give a general picture of the plankton in this area. Chlorophyll a concentrations in the GREAT I region were measured by Megard et al. (1978) and Flynn (1975). The study by Flynn, encompassing a 1-1/2 year time period, is valuable in assessing the chlorophyll a and phaeophytin concentrations

of Pool 3. Williams (1962) and the Minnesota Department of Health (1947) compiled phytoplankton population data from Pools 1-6. Measurements of primary production in a reach of the Mississippi River near Monticello, Minnesota were made from September 1973 to September 1974 by Mischuk (1976). This study was important in determining the effect of heated condensor cooling water on primary production downstream. The most comprehensive published surveys in the GREAT II area were conducted by Industrial BIO-TEST Laboratories (1970, 1971, 1972a and b, 1973a and b, 1974a and b, 1975a and b) and NALCO Environmental Sciences (1976). Extensive monitoring of phytoplankton populations in Pool 14 was used to assess any biological changes due to Quad-Cities Station operation. Heffelfinger (1973) sampled plankton and chemical and physical parameters at three locations in Pool 20. This study is a good general description of the habitat of Pool 20. Phytoplankton communities in Pool 19 were documented by Gale and Lowe (1971) in a study of phytoplankton ingestion by clams.

Recommendations: Although there are many publications about surveys done in Pool 14 and Pools 1-6, little work has been done elsewhere on the river. In order to better assess the algal community in other areas of the river, phytoplankton studies (combined with other aquatic sampling) should be undertaken.

Literature Cited:

Ernest, P. R. 1967. Analysis of the population of Stephanodiscus nigarae in Pool 6 of the Mississippi River by membrane filtration. B. A. Thesis, St.Mary's College, Winona, MN. 27 pp.

Flynn, M. T. 1975. Primary production and chlorophyll a content of phytoplankton during 1973-1974 in pool No. 3 of the Upper Mississippi River near Red Wing, Minnesota. B. A. Thesis, St. Mary's College, Winona, MN. 73 pp.

Gale, W. F. and R. L. Lowe. 1971. Phytoplankton ingestion by fingernail clam (*Sphaerium transverum*) in Pool 19, Mississippi River. Ecology. 52: 507-513.

Heffelfinger, J. A. 1973. A season survey of certain physical and chemical factors and plankton at three locations in Pool 20 of the Mississippi River. Unpublished M.S. Thesis. Western Ill. Univ., Macomb, IL.

Industrial BIO-TEST Laboratories, Inc. 1970. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1969 through June 1970). Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1971. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1970 throught December 1970). Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1972a. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (April 1971 through December 1971). 3 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1972b. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972). 2 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1973a. M. P. Locke and H. O. Eiler, eds., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1974a. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1974b. R. P. Markel, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co. Chicago, IL.

____________. 1975b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (February 1975 through July 1975). Prepared for Commonwealth Edison Co. Chicago, IL.

LaFosse, Sr. M. 1970. An estimate of the production rate of Asterionella formosa from mud and sand substrates at varying depths within a slough of the Upper Mississippi River, Pool No. 6. M.S. Thesis., St. Mary's College, Winona, MN.

Megard, R. O., W. S. Combs, Jr. and J. C. Settles. 1978. Planktonic algae, photosynthesis, and oxygen in the Mississippi River at Minneapolis and St. Paul, Minnesota. Contract MWCC # 469 for Metropolitan Waste Control Commission St. Paul, MN. 54 pp.

Minnesota Department of Health. 1947. Phytoplankton data from Lock and Dam nos. 2, 3, 4, 5 and 6. Unpublished. . 1948a. Phytoplankton data, Hastings to Lock and Dam 4. Unpublished.

Mischuk, M. W. 1976. Primary productivity in the Mississippi River near Monticello, Minnesota. M.S. Thesis, St. Cloud State University. St. Cloud, MN. 110 pp.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co. Chicago, IL.

Reinhard, E. G. 1930. The plankton ecology of the Upper Mississippi (Minneapolis to Winona). Ph.D. Thesis, Univ. of Minn., Minneapolis, MN.

Torborg, U. A. 1970. An estimate of the production rate of Stephanodiscus nigarae from mud and sand substrates at varying depths within a slough of the Upper Mississippi River, Pool 6. M.S. Thesis, St. Mary's College, Winona, MN.

Williams, L. G. 1962. Plankton population dynamics. Publ. Health Pub. No. 663. Suppl. 2.

Zeis, Sr. L. 1970. An estimate of the production rate of Fragilaria capucina from mud and sand substrates at varying depths within a slough of the Upper Mississippi River, Pool No. 6. M.S. Thesis., St. Mary's College, Winona, MN.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

2. Zooplankton

a. GREAT I

For ease of discussion, the zooplankton of GREAT I, II and III will be described together.

Information: Thirty-one references on zooplankton of the Upper Mississippi River and six general references on zooplankton of major tributaries or freshwater lakes were reviewed (Tables 4-6). Recent population studies were conducted by several investigators in Pool 3. Plankton ecology was also studied from Minneapolis to Winona to give a relative abundance and seasonal distribution of the organisms as well as ecological factors which may affect plankton life. Species composition was determined from other studies conducted on Minnesota lakes and ponds. Extensive zooplankton studies have been conducted in Pool 14 by Industrial BIO-TEST Laboratories Inc. (1972 a, b, 1973a, b, 1974a, b, 1975a, b) and NALCO Environmental Sciences (1976) which provide significant population data.

Voids: Zooplankton data were not available from Pools 1, 7-13, and 15-the Lower Stretch (Tables 4-6). No articles were found which described food habits of zooplankton.

Evaluation: Dieterman (1975) and Brandt and Foody (1972) conducted surveys in Pool 3 to study zooplankton population dynamics. Both were short-term studies and the results are inconclusive. A general picture of the plankton from Minneapolis to Winona was the topic of a thesis by Reinhard (1930). The study was conducted to relate the bacteriological, chemical, bio-chemical and chemical investigations of the area. Studies by Bartel and Holtkamp (1973), Hellberg (1948), Kingbury (1970) and Quade (1969) were performed in Minnesota lakes and ponds. Industrial BIO-TEST Laboratories, Inc. and NALCO Environmental

Sciences conducted extensive aquatic studies from 1972-1976 in the vicinity of the Quad-Cities Station during preoperational and operational periods. These data provide a nearly complete picture of the zooplankton community in Pool 14. Commonwealth Edison Company (1975) also reported zooplankton studies in Pool 14 as part of a 316a and b demonstration to the USEPA. An unpublished report by Czajkowski and Carpenter (1974) characterized in detail the zooplankton community near Cordova, Illinois (Pool 14), and concluded that densities and species richness were related to river flow. A study by Bernhard and Hughes (1975) evaluated zooplankton entrainment at Quad-Cities nuclear generating station. This study concluded that the open-cycle mode of condenser water flow had no apparent adverse affect on biotic communities in the Mississippi River near the station. Dorris (1958) and Berner (1947, 1951) studied plankton populations in the GREAT II area. A limnology survey of four lakes in the Mississippi River floodplain near Quincy, Illinois was conducted by Dorris (1958). Other general studies of plankton distribution were done by Emge et al. (1974a, b, c), Ragland (1974), Williams (1966), Eddy (1934), DeCosta (1964, 1968), Colbert et al. (1975, 1976), and the Federal Water Pollution Control Administration (1969).

Recommendations: Because of the intense studies done in Pool 14, it is not recommended that extensive studies be initiated in this area. In the other pools upstream and downstream of Pool 14 where little or no references on zooplankton were found, baseline investigations should be conducted. Zooplankton studies could be done in conjunction with other aquatic sampling.

Literature Cited:

Bartel, Sr. B. and Sr. M. C. Holtkamp. 1973. Qualitatve and quantitative analysis of net plankton of Lake Winona. M.S. Thesis, St. Mary's College, Winona, MN.

Berner, L.M. 1947. A limnological survey of the Missouri River from its mouth to the Iowa State line during the summer of 1945. M.S. Thesis, Univ. of Missouri. 167 pp.

Bernhard, H. F. and J. H. Hughes. 1975. Environmental monitoring at Quad-Cities nuclear generating station. Am. Nuc. Soc. Trans., Vol. 22, No. TANSAO, 22: 1-836.

Brandt, T. M. and L. T. Foody. 1972. Quantitative protozoan study during 1971-1972 ice conditions of the Upper Mississippi River. B.A. Thesis, St. Mary's College, Winona, MN. 26 pp.

Colbert, B. K., J. E. Scott, H. Johnson, and R. C. Solomon. 1975. Environmental Inventory and Assessment of navigation Pools 24, 25 and 26, Upper Mississippi and Lower Illinois Rivers: an aquatic analysis. USACE Waterways Experiment Station, MS. Final Rept. COL002.

Commonwealth Edison Company. 1975. Three-Sixteen (a&b) Demonstration, Quad-Cities Nuclear Station, Mississippi River. Chicago, IL.

Czajkowski, G. P., and G. F. Carpenter. 1974. Unpublished. Seasonal abundances of zooplankton in the Mississippi River near Cordova, IL..

De Costa, J. 1964. Latitudinal description of chydorid Cladocera in the Mississippi Valley, based on their remains in the surficial lake sediments. Invest. Ind. Lakes and Streams 6(2).

De Costa, J. 1968. Species diversity of chydorid fossil communities in the Mississippi Valley. Hydrobiologia. 32(3-4). 497-572.

Dieterman, S. 1975. A short-term impact study of the zooplankton populations dynamics in Pool 3 of the Mississippi River near the Northern States Power and Red Wing Nuclear Power Plant. M.S. Thesis, St. Mary's College, Winona, MN.

Dorris, T. C. 1958. Limnology of the Middle Mississippi River and adjacent waters. Lakes on the levied floodplain. Am. Midl. Nat. 59(1): 82-110.

Eddy, S. 1934. A study of freshwater plankton commumities. University of Illinois Bulletin 31(45): 6-90.

Emge, W. P., R. C. Solomon, J. H Johnson, C. R. Bingham, and B. K. Colbert. 1974a. Physical, Biological, and Chemical Inventory of Twenty-three Side Channels and four River Border Areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. 166 pp.

Emge, W. P., R. C. Solomon, J. H. Johnson, C. R. Bingham, and B. K. Colbert. 1974b. Physical, Biological, and Chemical Inventory of Twenty-three Side Channels and four River Border Areas, Middle Mississippi River. Army Engineer Waterways Experiment Station. Vicksburg, MS. 621 pp.

Emge, W. P., R. C. Solomon, J. H. Johnson, C. R. Bingham, and B. K. Colbert. 1974c. Physical, Biological, and Chemical Inventory of Twenty-three Side Channels and four River Border Areas, Middle Mississippi River. Army Engineer Waterways Experiment Station. Vicksburg, MS.. 621 pp.

Federal Water Pollution Control Administration. 1969a. Mississippi River Reconnaissance, Report of Samping in the vicinity of Dubuque, Iowa, and the Tributaries from Above Dubuque to Below Keokuk, Iowa, in both Iowa and Illinois. Chicago, Ill. Lake Michigan Basin Office. 169 pp.

Hellberg, J. M. 1948. A study of the vertical distribution of the plankton in Lake Itasca, Minnesota, during August 1947. M.A. Thesis, Univ. Minnesota.

Industrial BIO-TEST Laboratories, Inc. 1972a. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (April 1971 through December 1971). 3 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1972b. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972) 2 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1973a. M. P. Locke and H. O. Eiler, eds., Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1974a. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1975a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1975b. R. M. Gerhold, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (February 1975 through July 1975). Prepared by Commonwealth Edison Co. Chicago, IL.

Kingsbury, P. J. 1970. Calanoid Copepods from the forest to prairie transition in the Itasca Park Region of Minnesota. Iowa Acad. Sci. 77: 223-227.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co. Chicago, IL.

Quade, H. W. 1969. Cladoceran faunas associated with aquatic macrophytes in some lakes in Northwestern Minnesota. Ecology. 50(2):170-170.

Ragland, D. v. 1974. Evaluation of three side channels and the main channel border of the Middle Mississippi River as fish habitat. Springfield Va. prep. for U.S. Army. Eng. Waterways Experiment Station. AD-786 142.

Reinhard, E. G. 1930. The plankton ecology of the Upper Mississippi (Minneapolis to Winona). Ph.D. Thesis, Univ. of Minn., Minneapolis, MN.

Williams, L. G. 1966. Dominant planktonic rotifers of major waterways of the United States. Limnol. Oceanogr. 11: 83-91.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

3. Miscellaneous Organisms - Periphyton

a. GREAT I

The periphyton populations of GREATS II and III will be discussed in conjunction with GREAT I.

Information: A total of 28 citations relating to periphyton distribution in the Upper Mississippi River were reviewed (Tables 4-6). Most of the information from the GREAT I area can be found in Northern States Power Company's annual reports for Monticello and Prairie Island Nuclear Power Plants. The published reports in the GREAT II region are almost entirely limited to studies conducted in Pool 14.

Voids: Although there are 28 articles available on periphyton in the Upper Mississippi River all but two relate to monitoring near power plants. Most of the pools have not been sampled for periphyton (Tables 4-6).

Evaluation: The attached algal community of the Mississippi River near Monticello, Minnesota has had considerable investigation since 1969. Northern States Power Company (1969, 1970, 1972, 1973a and b, 1974) and Brook (1971) have conducted extensive multi-year monitoring near their Monticello and Prairie Island Nuclear Generating Plants to assess any possible adverse environmental impacts due to thermal effluents. Any severe impact to the algal community would probably be apparent in successive elements of aquatic life. Webber (1977) studied diatom populations on artificial and natural substrates near Monticello, Minnesota to determine the periphyton standing crop and compare artificial and natural substrate communities. Periphyton populations and prodution rates upstream and downstream of the Quad-Cities station were determined by Industrial BIO-TEST (1970, 1971, 1972a and b, 1974a and b, 1975a and b), NALCO Environmental Sciences (1976, 1977a and b, 1978), Commonwealth Edison

Company (1975), and Clark (1974). These studies are valuable in illustrating seasonal fluctuations and distributions of periphytic algal communities and may be regarded as comprehensive baseline data for any further studies in the Pool 14 area. River algae communities were discussed in relation to current, depth, temperature, light, turbidity and chemical parameters by Blum (1956). His work does not directly concern the Upper Mississippi River but can provide background information.

Recommendations: Periphyton populations have been extensively studied in Pool 14. Therefore, it should not be necessary to conduct monitoring prior to any Corps work in this area. Surveys should be conducted, however, after Corps activities have commenced to detect any possible adverse affects. Surveys in other areas of the river should be conducted prior to and after any planned Corps activities. To minimize costs, these studies should be combined with other aquatic monitoring.

Literature Cited:

Blum, J. L. 1956. The ecology of river algae. Bot. (5): 291-331.

Brook, A. J. 1971. Attached algae studies on the Mississippi River at Monticello - interim report. In Northern States Power Company environmental report, Monticello Nuclear Generating Plant, Northern States Power Company, Minneapolis, MN. 4 p.

Clark, L. H. 1974. Effects of Quad-Cities Nuclear Station operation on periphytic algae colonizing artificial substrates. Pap. pres. to Miss. River. Res. Consortium Ann. Meet. May 17-18.

Commonwealth Edison Company. 1975. Three-Sixteen (a&b) Demonstration, Quad-Cities Nuclear Station, Mississippi River. Chicago, Illinois.

Industrial BIO-TEST Laboratories, Inc. 1970. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1969 through December 1970). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1971. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1970 through December 1970). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1972a. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (April 1971 through December 1971). 3 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1972b. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972). 2 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1973a. M. P. Locke, and H. O. Eiler, eds., Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1974a. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co., Chicago, Ill.

______________. 1975a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co., Chicago, Ill.

______________. 1975b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (February 1975 through July 1975). Prepared for Commonwealth Edison Co., Chicago, IL.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1977a. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1977 through July 1977). Prepared for Commonwealth Edison, Co., Chicago, IL.

__________. 1977b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1978. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1977 through January 1978). Prepared for Commonwealth Edison Co., Chicago, IL.

Northern States Power Company. 1969. Environmental monitoring program annual report, Monticello Nuclear Generating Plant. Monticello, MN.

__________. 1970. Description of the environmental monitoring program for the Prairie Island Nuclear Generating Plant near Red Wing, MN.

__________. 1972. Monticello Nuclear Generating Plant. Unit 1. Mississippi River flow and Temperature Data. Minneapolis, MN. 15 pp.

__________. 1973a. Monticello Nuclear Generating Plant. Unit 1. Environmental Monitoring and Ecological Studies Program. Annual Report 1972. Minneapolis, MN. 576 pp.

__________. 1973b. Prairie Island Nuclear Generating Plant. Units 1 and 2. Environmental Monitoring and Ecological Studies Program. Annual Report. 1972. Minneapolis, MN. 754 pp.

__________. 1974. Monticello Nuclear Generating plant. Unit 1. Semiannual Operating Report No. 7, January - June 1974. Minneapolis, MN. 118 pp.

Webber, O. K. 1977. Diatom populations observed on artificial and natural substrates in the Mississippi River near Monticello, MN. M.S. Thesis, St. Cloud Univ., St. Cloud, MN.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

C. Molluscs

1. Freshwater Mussels

a. GREAT I

Information: Sixty-five articles and reports concerning freshwater mussels (naiads) of the GREAT I Region of the Upper Mississippi River (Pools 1-10) were compiled and reviewed (Table 7). The content of the articles was quite diverse and included topics such as taxonomy, life history, ecology, general surveys and the mussel industry.

Information regarding freshwater mussels of the Upper Mississippi River has been published from the early 1800's through the present time. Exploration of the Northwest Territory included lists of Mollusca from areas along the Mississippi River. Numerous recent studies have been conducted regarding endangered species and the mussel industry.

Voids: Although there are a total of 65 articles referring in general to the GREAT I Region of the Mississippi River only 39 of these articles are specific to this region. Only a few of the Mississippi River studies involving research into the life history, physiology, taxonomy and propagation of mussels were conducted in the GREAT I area.

Most of the environmental studies in this reach of the Mississippi River concerned the mussel fauna near the main channel while backwater and slough survey information is absent.

The mussel fauna of Pools 4-10 have been surveyed by many researchers; however, Pools 1-3 have had few investigations. The species lists, catalogues and taxonomic keys provide good general information, but most of this literature is not recent and does not have site-specific data.

Evaluation: In the late 1800's the use of freshwater mussel shells to make pearl buttons started a major industry in America. However, the enormous demand for freshwater mussel buttons and pearls resulted in a depletion of mussel beds in many streams. The threatened extinction of certain species instigated numerous studies on the Mississippi River to evaluate mussel resources (Coker 1914, 1921; Grier 1922, 1926; Grier and Mueller 1922-1923; Ellis 1931a, 1931b) and to study mussel ecology and physiology (Isely 1914; Allen 1914, 1921; Churchill and Lewis 1924; Ellis, Merrick and Ellis 1931; Chamberlain 1931). Investigations by Lefevre and Curtis (1908, 1912), Howard (1914, 1922), Coker et al. (1921), Barney (1922) and Jones (1950) were concerned with the artificial propagation and culturing of freshwater mussels in order to replenish the depleted populations. Much of this research was conducted at the Fairport Biological Laboratory in Iowa. In recent times, the cultured pearl industry and the Endangered Species Act created new concerns and reasons for researching the freshwater mussels.

The surveys conducted by Grier in the 1920's (Grier 1922 and 1926) were intensive samplings of the mussel resources in the areas of the Mississippi River which are now Pools 4-7. In 1930 and 1931, Ellis surveyed numerous sites in the GREAT I Region from Lake Pepin (Pool 4) downstream to Prairie du Chien, Wisconsin which is now in Pool 10 (van der Schalie and van der Schalie 1950). These two surveys were initiated during a period of heavy mussel harvesting for the pearl button industry to document the mussel resource of the Upper Mississippi River.

In the 1960's and 1970's interest was renewed in the Mississippi River mussels due to the concern for the mussel resource of the cultured pearl industry and for mussel species which were declared federally

endangered. The resulting mussel research provided excellent modern records regarding distribution, ecology and abundances. The Wisconsin Department of Natural Resources surveyed Pools 4, 5, 6, 7 and 9 in 1964 (Finke 1966) and Pools 3-8 during 1977-1978 (Fernholz 1977, Larsen and Holzer 1978, and Thiel et al. 1980, in progress). The Iowa Department of Conservation sampled the mussel communities in Pools 9 and 10 of the Mississippi River in 1976 (Ackerman 1976a and 1976b). Corps of Engineers dredge sites throughout the GREAT I reach of the Mississippi River were surveyed for the presence of freshwater mussels by Fuller in 1977 (Fuller 1978) and during 1978-1979 (Fuller 1980, in progress). The relative abundance and growth of mussels in Pools 8, 9 and 10 were determined by Coon et al. in 1975 (Eckblad et al. 1976, Coon et al. 1977). During 1973-1977, the mussel fauna in the Wisconsin portion of the Mississippi River was documented by Mathiak (1979).

Other important surveys in localized areas of the GREAT I Region include studies in Pool 4 (Wilson and Danglade 1914, Southall 1925 and Morrison 1959), Pool 7 (Havlik 1977a), Pool 8 (Havlik 1977b) and Pool 10 (Havlik and Stansbery 1977). Species lists from various locations in the GREAT II area (Barnes 1823, Cooper 1855, Shimek 1888 and 1921, Keyes 1889, Drew 1890, Call 1895, Baker 1905 and 1928, Dawley 1947 and Perry 1979) also provide useful information concerning distribution and, in some instances, ecology of the mussels.

Recommendations: Certain areas and habitats in the GREAT I Region of the Upper Mississippi have little or no information regarding their mussel fauna. Most recent mussel surveys have been conducted near the main channel and usually have not investigated the backwater and slough areas. Future surveys or impact studies should include these habitats to further the knowledge of the total Mississippi River mussel fauna.

The only recent mussel surveys of Pools 1 and 2 were conducted by Fuller (1978) and he reported few live species to be present. These two pools are heavily polluted by the Twin-Cities and need further investigations of their sparse mussel fauna and the specific reasons for their apparent degraded communities. Additional information is also needed for the mussel fauna of Pool 3.

The decline of certain mussel species in the GREAT I Region of the Upper Mississippi River needs to be researched to determine the cause of the decreasing populations. The freshwater mussel fauna, in general, needs monitoring to assure maintenance of a healthy mussel community.

Additional freshwater mussel research is needed in unresolved problem areas such as taxonomic separations of certain species and the impact of dredging, sedimentation, the cultured pearl industry and non-point source discharges on the mussels of the Upper Mississippi River.

Literature Cited:

Ackerman, G. L. 1976a. Survey of freshwater mussels of the Upper Mississippi River, Pools 9 through 13. Iowa Cons. Comm. Proj. No. 76-II-C-35. pp. 196-200.

__________. 1976b. Survey of freshwater mussel of the Upper Mississippi River. UMRCC Spec. Rept. 9 pp.

Allen, W. R. 1914. The food and feeding habits of freshwater mussels. Biological Bulletin, 27: 127-147.

__________. 1921. Studies of the biology of freshwater mussels. Experimental studies of the food relationships of certain Unionidae. Biological Bulletin, 40:210-241.

Baker, F. C. 1905. The molluscan fauna of McGregor, Iowa. Trans. Acad. Sci. St. Louis. 15:249-256.

__________. 1928. The fresh water Mollusca of Wisconsin, Part II, Pelecypoda. Bull. Wis. Geol. Nat. Hist. Surv. No. 70. P. 310-495.

Barnes, D. W. 1823. On the genera Unio and Alasmodonta; with introductory remarks. American Journal of Science and Arts 6:107-127.

Barney, R. L. 1922. An indication of the value of artificial propagation of pearly mussels. Nautilus 36(2):53-58.

Call, R. E. 1895. A geographic catalogue of the Uniondae of the Mississippi Valley. Bull. Des Moines Acad. Sci. 1:5-57.

Chamberlain, T. K. 1931. Annual growth of fresh-water mussels. Bull. U.S. Bur. Fish., Vol. XLVI, 1930 (1931). Bur. of Fish. Doc. No. 1103: 713-739.

Churchill, E. P., Jr. and S. I. Lewis. 1924. Food and feeding in fresh-water mussels. Bull. U.S. Bur. Fish. 39:437-471.

Coker, R. E. 1914. Water-power development in relation to fishes and mussels of the Mississippi. Rept. U.S. Comm. Fish 1913, App 8:1-28.

__________. 1921. Freshwater mussel industry. Rept. of U.S. Comm. Fish., Washington, 1917-18, p. 39.

__________. A. F. Shira, H. W. Clark, A. D. Howard. 1921. Natural history and propogation of fresh-water mussels. Bulletin of the Bureau of Fisheries, 37: 77-181. Separately issued as Bureau of Fisheries Document No. 893.

Coon, T. G., J. W. Eckblad, and P. M. Trygstad. 1977. Relative abundance and growth of mussels (Mollusca: Eulamelli branchia) in Pools 8, 9 and 10 of the Mississippi River. Iowa, USA. Fresh. Biol. 7(3): 279-286.

Cooper, W. S. 1855. List of shells collected by Mr. Schoolcraft, in the western and northwestern territory. In: H. R. Schoolcraft, summary narrative of an explanatory expedition to the sources of the Mississippi River, in 1820: resumed and completed, by the discovery of its origin in Itasca Lake, in 1822. 515-518 pp. Lippincott, Grambo, and Co., Philadelphia.

Dawley, C. 1947. Distribution of aquatic Mollusks in Minnesota. Amer. Midl. Nat. 38:671-497.

Drew, G. 1890. The unios of Iowa. Thesis, State University of Iowa, Ames. 93 pp.

Eckblad, J. W., T. G. Coon, and P. M. Trygstad. 1976. Growth and abundance of Unionacea mussels in Pools 8, 9, and 10 of the Upper Mississippi River. Pap. Pres. at 24th Ann. Mtg. N. Am. Benthological Soc., LaCrosse, WI., March 24-26, 1976.

Ellis, M. M. 1931a. Some factors affecting the replacement of the commercial fresh-water mussels. U.S. Bur. Fish. Circ. 7:1-10.

__________. 1931b. A survey of conditions affecting fisheries in the Upper Mississippi River, U.S. Bur. Fish Circ. 5:1-18.

Ellis, M. M., A. D. Merrick and M. D. Ellis. 1931. The blood of North American fresh-water mussels under normal and adverse conditions. Bull. U.S. Bur. Fish. 46(1097): 509-542.

Fernholz, W. B. 1977. Survey of mussels in the Upper Mississippi River - Pools 3 through 8. Wis. Dept. Res., Fish Div., 1976-77. Sum. Rept. No. 12. 3 pp.

Finke, A. H. 1966. Report of a mussel survey in Pools 4A (Lake Pepin), 5, 6, 7, and 9 of the Mississippi River during 1965. Wis. Cons. Dept. Rept. unpub. mimeo. 5 pp. + maps and tables.

Fuller, S. L. H. 1978. Freshwater mussels (Mollusca: Bivalvia: Uniondale) of the Upper Mississippi River: Observations of selected sites within the 9-foot channel navigation project on behalf of the United States Army Corps of Engineers. Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania. 401 pp.

__________. 1980, in progress. Freshwater mussels (Mollusca: Bivalvia: Uniondale) of the Upper Mississippi River. Observations at selected Sites within the 9-foot channel navigation project on behalf of the United States Army Corps of Engineers. Academy of Natural Sciences of Philadelphia, Pennsylvania. Grant, U. S. 1887. Notes on the molluscan fauna of Minnesota. Ann. Rept. Geol. and Nat. Hist. Surv. Minn. 16:481-484.

Grier, N. M. 1922. Final report on the study and appraisal of mussel resources in selected areas of the Upper Mississippi River. Am. Midl. Nat. 8: 1-33.

__________. 1926. Report on the study and appraisal of mussel resources in selected areas of the Upper Mississippi River. Am. Midl. Nat. 10: 89-110.

Grier, N. M., and J. F. Mueller. 1922-1923. Notes on the naiad fauna of the Upper Mississippi River. II. The naiads of the Upper Mississippi drainage. Nautilus, 36: 46-49, 96-103.

Havlik, M. E. 1977a. Naiad mollusks collected for bioassay studies from Rosebud Island, Pool 7 of the Mississippi River, above LaCrosse, WI. Contr. NO. DACW37-77M-2193. St. Paul Dist. U.S. Army Corps of Engr. Unpub. Rept.

__________. 1977b. A naiad mollusk survey of the Mississippi River adjacent to Isle Le Plume at LaCrosse, WI. Contr. with City of La Crosse, Wis. Unpubl. Rept.

Havlik, M. E. and D. H. Stansbery. 1977. The naiad mollusks of the Mississippi River in the vicinity of Prairie du Chien, WI. Ann. Rept. Am. Malacological Union.

Howard, A. D. 1914. Experiments in propagation of freshwater mussels of the Quadrula group. App. 4, Rep. U.S. Comm. Fish., 1913 (Doc. No. 801). 52 pp.

__________. 1922. Experiments in the culture of fresh-water mussels. Bull. U.S. Bur. Fish. 38: 1-89.

Iseley, F. B. 1914. Experimental study of the growth of migration of fresh-water mussels. App. 3, Rep. U.S. Com. Fish. 1913:1-24.

Jones, R. O. 1950. Propagation of freshwater mussels. Prog. Fish-Cult., 12(1): 13.

Keyes, C. R. 1889. An annotated catalogue of the Mollusca of Iowa. Bulletin of the Essex Institute, 20: 1-25.

Lefevre, G. and W. C. Curtis. 1908. Experiments in the artificial propagation of fresh-water mussels. Bull. U.S. Bur. Fish. 38: 615-626.

Lefevre, G. and W. C. Curtis. 1912. Studies of the reproduction and artificial propagation of fresh-water mussels. Bull. U.S. Bur. Fish. 30: 103-201.

Larsen, T. R. and J. A. Holzer. 1978. Survey of mussels in the Upper Mississippi River, Pools 3 through 8. Interim Prog. Rep. Wis. Dept. Nat. Res., LaCrosse, Wis. Unpubl.

Mathiak, H. A. 1979. A river survey of the unionid mussels of Wisconsin 1973-1977. Sand Shell Press, Horicon, Wisc. 75 pp.

Morrison, M. J. 1959. Ecology of the dams of Lake Pepin. B.A. Thesis. St. Mary's College, Winona, MN. 50 pp.

Perry, E. W. 1979. A survey of Upper Mississippi River mussels. In: Rasmussen, J. L., editor. A compendium of fishery information on the Upper Mississippi River. Second Edition. Upper Mississippi River Conservation Commission. Rock Island, IL. pp. 118-139.

Shimek, B. 1888. The Mollusca of eastern Iowa. Iowa University Natural History Bulletin, 1: 56-81.

__________. 1921. Mollusks of the McGregor, Iowa region I. Iowa Conserv. Vol. No. 4, Oct.-Dec. 5 p.

Southall, J. B. 1925. Mussel survey of Lake Pepin in 1924. Economic Circular, No. 57, U.S. Bur. Fish., pp. 1-3.

Thiel, P., M. Talbot and J. Holzer. 1979. Survey of mussels in the Upper Mississippi River pools 3 through 8. In J. L. Rasmussen (ed.) In Press. Proceedings of the UMRCC Symposium on Upper Mississippi River bivalve mollusks. Upper Mississippi Conservation Committee.

van der Schalie, H. and A. van der Schalie. 1950. The mussels of the Mississippi River. Am. Midl. Nat. 44(2): 448-466.

Wilson, C. B. and E. Danglade. 1914. The mussel fauna of central and northern Minnesota. App. V to the report of the U.S. Commissioner of Fisheries for 1913. Separately issued as Bur. of Fish. Document No. 803.

b. GREAT II

Information: Seventy-nine articles and reports regarding freshwater mussels of the GREAT II Region of the Mississippi River (Pools 11-22) were compiled and reviewed (Table 8). Information regarding the distribution, life history, taxonomy, ecological preferences and economic value of freshwater mussels was presented in a variety of publications. Data presented in lists, surveys and catalogues provided much useful information regarding the life history and distribution of the Mississippi River mussels.

Voids: The GREAT II Region of the Mississippi River has been surveyed by many researchers and there appears to be no voids in distributional data. As found for in GREAT I, the surveys were primarily at border channel locations and not in backwater areas.

Although there have been many studies in the past at the Fairport Biological Laboratory on the effects of the pearl button industry, on mussels, there has been no recent intensive research to determine the impact of the gravel mining and cultured pearl industries on the freshwater mussel populations and habitats in the Mississippi River.

Evaluation: The extensive and localized surveys of the GREAT II area of the Upper Mississippi River have provided comprehensive information concerning freshwater mussel distribution. Some of the more intensive surveys include the studies by Ellis (van der Schalie and van der Schalie 1950) in the areas of Pools 13-16 and 18-22; the Iowa Department of Conservation in Pools 11-13 (Ackerman 1976a, 1976b); Fuller (1978) in Pools 11 and 13-21; Freitag (1978) in Pools 16, 18, 19 and 21; Perry (1979) in Pools 11-22; and Hazleton Environmental Sciences in Pools 12, 13, 15-20, 22 and 24 (Brice and Lewis 1980, in progress). Localized surveys and lists have also

been reported by Mathiak (1979) in Pools 11 and 12; Cawley (1977, 1978) in Pool 12, Davis and Cawley (1975) in Pool 12; Baker (1903) in Pool 13; Lewis and Brice (1977) and Lewis (1979) in Pool 14; Waters (1976, 1977) in Pools 14-19; Ecology Consultants, Inc. (1977) in Pool 15; Nelson (1979) in Pool 15; NUS Corporation (1979) in Pool 15; van der Schalie and Bates (1976) in Pool 19; and Pogge et al. (1978) in Pool 22. In addition, there are numerous other species lists, catalogues, surveys and taxonomic keys in bordering states which provide valuable historic and modern information regarding the Mississippi River mussel fauna. The species lists and catalogues prepared by Witter (1878, 1883), Marsh (1887-1889), Call (1885), Shimek (1888), Keyes (1889) and Baker (1906) provide particularly valuable distribution and ecology information.

The freshwater mussel research at Fairport Biological Station investigated numerous areas of mussel life history, ecology, propagation and management which before had been unknown. Although this information was collected before construction of the present lock and dam system and maintenance of the 9-foot channel, much of the data is still applicable and can also be utilized in the GREAT I and III Regions.

Recommendations: It appears that the mussel fauna in the GREAT II reach of the Mississippi River has been surveyed in enough detail to describe the populations presently colonizing each pool. No further general surveys appear to be needed. General areas of study which were discussed in the GREAT I recommendations such as backwater surveys, community monitorings, taxonomic differentiations and various pollution impact assessments are also advised for the GREAT II Region.

Although the Fairport Biological Station conducted numerous research projects regarding the freshwater mussels in the Mississippi

River, no definitive work has been conducted on the modern day problems of dredging, industry and new chemical pollutants, such as heavy metals and synthetic chemicals, need to be researched for individual or synergistic negative influences on the mussel fauna.

Literature Cited:

Ackerman, G. L. 1976a. Survey of freshwater mussels of the Upper Mississippi River, Pools 9 through 13. Iowa Cons. Comm. Proj. No. 76-II-C-35. pp. 196-200.

____________. 1976b. Survey of freshwater mussels of the Upper Mississippi River. UMRCC Spec. Rept. 9 pp.

Baker, F. C. 1903. Shell collecting on the Mississippi (Savanna, Illinois). Nautilus 16:102-105.

____________. 1906. A catalogue of the mollusca of Illinois. Ill. State Lab. Nat. Hist. Bull. 7(6):53-136.

Brice, J. R. and R. B. Lewis. 1980, in progress. A survey of selected dredge sites for the presense of freshwater mussels within the Rock Island District of the U.S. Army Corps of Engineers. Prepared by Hazleton Environmental Sciences, Inc.

Cawley, E. T. 1977. Study of the environmental impacts of dredging by the Dubuque Sand and Gravel Company in Pool 12 of the Upper Mississippi River. E. T. Cawley, Dubuque, Iowa. 7 pp.

____________. 1978. Preliminary report on clam survey on Dubuque bridge site. Environ. Res. Cen., Loras College, Dubuque, Iowa. 8 pp.

Davis, S., and E. T. Cawley. 1975. A survey of the freshwater mussels (Pelecypoda) of the Mississippi River in Pool 12. E. T. Cawley, Dubuque, Iowa. Pp. I-5 and 5 p.

Ecology Consultants, Inc. 1977. Sylvan slough mussel study for new Moline bridge at Rock Island Arsenal, Illinois. Rept. to U.S. Army Corps of Eng., Omaha Dist. 12 pp.

Freitag, T. M. 1978. A survey of selected dredge sites for the presence of fresh water mussels within the Rock Island District, U.S. Army Corps of Engineers, Operations Division, 7 p. + appendices.

Fuller, S. L. H. 1978. Freshwater mussels (Mollusca: Bivalvia: Unionidae) of the Upper Mississippi River. Observations at selected sites within the 9-foot channel navigation project on behalf of the United States Army Corps of Engineers. Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania. 401 pp.

Keyes, C. R. 1889. An annotated catalogue of the Mollusca of Iowa. Bulletin of the Essex Institute, 20: 1-25.

Lewis, R. B. 1979. Benthic macroinvertebrate study. In: C. A. Altstaetter ed. Environmental Monitoring in the Mississippi River near Quad-Cities station (1968-1978). NALCO Environ. Sci. Rept. to Comm. Ed. Co., Chicago. pp. 6.1-6.148 + appendix.

Lewis, R. B., and J. R. Brice. 1977. Freshwater mussel survey. In: R. M. Gerhold, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (Feb. 1976-Jan. 1977). NALCO Environ. Sci. Rept. to Comm. Ed. Co., Chicago. pp. 535-554.

Marsh, W. A. 1887-1889. Brief notes on the land and freshwater shells of Mercer Co., Ill. Conchologists' Exchange 1(8):42-43, 1 (9+10): 50-51, 1 (11):62-63, 1(12):74-75, 2(1):4-5, 2(2):20-21, 2(3):36-37, 2(4):48-50, 2(5):65-67, 2(6):80-81, 2(7):90-92, 2(3):103-104, 2(9): 110-111. Nautilus 3(2):23-24, 3(3):34-35.

Mathiak, H. A. 1979. A river survey of the unionid mussels of Wisconsin 1973-77. Sand Shell Press, Horicon, Wisc. 75 pp.

Nelson, D. A. 1979. Mussel survey for local flood protection project, Monline, Illinois. Prepared by U. S. Army Corps of Engineers, Rock Island District. 6 pp. + figures.

NUS Corporation. 1979. The naiads (Mollusca) of Sylvan Slough, Mississippi River near Moline, Illinois; an experiment in naiad relocation. Draft Contract Report #CACA45-78-M-0368, Omaha District Corps of Engineers. 11 pp.

Perry, E. W. 1979. A Survey of Upper Mississippi River mussels. In: Rasmussen, J. L. editor. Compendium of fishery information on the Upper Mississippi River. Second Edition. Upper Mississippi River Conservation Commission, Rock Island, Illinois. pp. 118-139.

Pogge, A., G. Schneider and J. Ostdliek. 1978. Freshwater mussel survey in Pool 22 of the Mississippi River near Saverton, Missouri. Submitted by Borg-Warner Chemicals, Parkersburg, West Virginia to the District Engineer, Rock Island District, Corps of Engineers, Rock Island, Illinois.

Shimek, B. 1888. The Mollusca of eastern Iowa. Iowa University Natural History Bulletin, 1: 56-81

van der Schalie, H. and J. Bates. 1976. A survey of fresh-water mussels near a proposed power plant site. Conducted for Iowa-Illinois Gas and Electric Company, Davenport, Iowa.

Waters S. 1976. Area Survey-Mississippi River, 1976. Steamboat Slough (R. M. 503-505.6, Pool 14) and Rush Chute (R. M. 406-410.4, Pool 19). Iowa Cons. Comm. Proj. No. 76-III-C-14. pp. 47-53.

Waters, S. 1977. Freshwater mussels of the Upper Mississippi River Pools 14-19. Iowa Cons. Comm. Proj. No. 77-III-p-18. pp. 120-130.

Witter, F. M. 1878. List of Mollusca collected at Muscatine, Iowa, U.S.A. Quarterly J. of Conchology. pp. 383-394.

___________. 1883. The Mollusca of Muscatine County and vicinity. S. E. Cassino and Co., Boston. 24 p.

c. GREAT III

Information: Forty-one articles and reports concerning freshwater mussels of the GREAT III Region (Pools 24 through the Lower Stretch) were compiled and reviewed (Table 9). Most of these were not Pool specific but were, instead, surveys of the GREAT III Region or entire Upper Mississippi River in general.

Voids: The GREAT III Region has the least amount of freshwater mussel information of any of the reaches of the Upper Mississippi River. Information concerning the mussel fauna in the Lower Stretch of the Upper Mississippi River is particularly sparse.

Evaluation: Although there are few mussel survey reports from the GREAT III reach of the Upper Mississippi River, the work by Ellis (van der Schalie 1950) and Perry (1979) provide excellent distribution records for this area. The data from Ellis's survey described the distribution and relative abundance of the freshwater mussels in specified zones of the Mississippi which are now Pools 24, 25 and 26. The mussel fauna of the entire GREAT III Region was surveyed and documented by Perry (1979). The few number of live specimens recorded downstream from the mouth of the Missouri River demonstrates the poor mussel communities in this section of the Mississippi River. The historically poor mussel fauna in the Lower Stretch of the Upper Mississippi River (Bartsch 1916) and resulting lack of interest by the mussel industry are the probable reasons for the dearth of literature for this reach. Other valuable distribution data were collected in Pool 24 by Brice and Lewis (1980, in progress).

State species lists for Illinois (Baker 1906, Parmalee 1967) and Missouri (Utterback 1915-1916) provide good general accounts of the

Mississippi River mussel fauna. Parmalee's work, while not site-specific, contains the only recent information.

Although there is a void of mussel research data concerning the GREAT III Region, the studies conducted in the GREAT I and II reaches of the Mississippi River can be applied to the similar GREAT III mussel fauna.

Recommendations: The lack of distribution data in the GREAT III region, particularly the lower stretch of the Upper Mississippi River, reveals the need for further survey information in this reach. The general areas of needed research in the Mississippi River which were described in the GREAT I recommendations such as backwater surveys, community monitorings, taxonomic differentiations and various pollution impact assessments are also suggested for the GREAT III area mussel populations. This is especially important in the GREAT III reach of the Mississippi River where the nationally endangered species Potamilus (= Proptera) capax, the "Fat Pocketbook", has been reported.

Literature Cited:

Baker, F. C. 1906. A catalogue of the Mollusca of Illinois. Ill. State Lab. Nat. Hist. Bull. 7)6):53-136.

Bartsch, P. 1916. The Missouri River as a faunal barrier. Nantilus 30:92.

Brice, J. R. and R. B. Lewis. 1980, in progress. A survey of selected dredge sites for the presense of freshwater mussel within the Rock Island District of the U.S. Army Corps of Engineers. Prepared by Hazleton Environmental Sciences, Inc.

Parmalee, P. W. 1967. The fresh-water mussels of Illinois. Ill. State Mus. Popular Sci. Serv. 8 1-108.

Perry, E. W. 1979. A survey of Upper Mississippi River mussels. In: Rasmussen, J. L., editor. A compendium of fishery information on the Upper Mississippi River. Second Edition. Upper Mississippi River Conservation Commission, Rock Island, Illinois. pp. 118-139.

Utterback, W. I. 1915-1916. The naiades of Missouri. Am. Midl. Nat. 4(3):41-533.

van der Schalie, H. and A. van der Schalie. 1959, The mussels of the Mississippi River. Am. Midl. Nat. 44(2):448-466.

2. Fingernail Clams

a. GREAT I

For the discussion of fingernail clams, all three GREAT Regions will be combined.

Information: Twenty-one articles and reports specifically dealing with the fingernail clams (Sphaeriidae) of the Upper Mississippi River were compiled and reviewed (Tables 7-9). In addition to these publications, other information concerning fingernail clams is found in general benthic macroinvvertebrate surveys which are discussed in the Benthos section (Section D) of this report.

Studies of the Mississippi River fingernail clams have been conducted almost exclusively in Pool 19 due to the extensive fingernail clam beds unique to this pool and the large number of migrating diving ducks which feed on them (Thompson 1969).

Voids: Although there have been intensive investigations of the fingernail clam community of Pool 19, the remainder of the Upper Mississippi River has had few studies concerning the Sphaeriidae, except for general benthos surveys.

Most of the species lists and catalogues regarding fingernail clams in the Upper Mississippi River are very old and do not provide site-specific information. There are no recent lists of the fingernail clams in the Upper Mississippi River.

Evaluation: The research conducted by Gale (1969, 1972, 1973, 1975, 1976 and 1977); Gale et al. (1969); Gale and Lowe (1971); Jude (1968, 1973); Rogers (1973, 1976); and Thompson and Sparks

(1977) provides excellent data regarding the distribution, life history, population dynamics and ecological importance of the fingernail clam community in Pool 19. This literature also provides valuable information concerning the fingernail clams of the Upper Mississippi River in general.

The catalogues, taxonomic keys and species lists provide valuable records regarding fingernail clam distribution in specific reaches of the Mississippi River (Pratt 1876, and Marsh 1887-1889) and information concerning distribution and ecology in states bordering the Mississippi River (Shimek 1888; Keyes 1889; Baker 1906, 1928; and Roy 1963).

Numerous other articles and reports discussing general benthos surveys of the Upper Mississippi River also provide useful distribution and density information on the fingernail clams.

Recommendations: Recent reports of decreased densities of fingernail clams in Pool 19 of the Mississippi River should be researched to determine the reason for this apparent population decline.

The fingernail clam communities of the Upper Mississippi River should be surveyed periodically to monitor the health of each population, especially the important clam beds in Pool 19. These surveys would provide site specific data concerning finernail clam densities, species composition and distribution. Additional recent information could be gleaned from general benthos surveys and then compiled into one document. This reference document could be compared with extant or future data to describe changes in the clam populations due to water quality or physical changes.

Literature Cited:

Baker, F. C. 1906. A catalogue of the Mollusca of Illinois. Ill. State Lab. Nat. Hist. Bull. 7(6):53-136.

______. 1928. The fresh water Mollusca of Wisconsin, Part II, Pelecypoda. Bull. Wis. Geol. Nat. Hist. Surv. No. 70. P. 310-495.

Gale, W. F. 1969. Bottom fauna of Pool 19, Mississippi River with emphasis on the life history of the fingernail clam, Sphaerium transversum. Ph.D. Thesis. Ia. St. Univ., Ames. 234 pp.

______. 1972. Seasonal variability on calyculism in Sphaerium transversum (Say). Nautilus. 86(1):20-22.

______. 1973. Predation and parasitism as factors affecting Sphaerium transversum (Say) populations in Pool 19, Mississippi River. Res. Pop. Ecol. Vol. 14(2):169-187.

______. 1975. Bottom fauna of a segment of Pool 19, Mississippi River, near Fort Madison, Iowa, 1967-1969. Ia. St. Jour. Res. 49(4 pt. 1):352-372.

______. 1976. Vertical distribution and burrowing behavior of the fingernail clam, Sphaerium transversum. Malacologia. Vol. 15(2):401-409.

______. 1977. Growth of the fingernail clam, Sphaerium transversum (Say) in Pool 19, Mississippi River. Ecology. Vol. 52(3):507-513.

Gale, W. F., D. J. Jude, and R. G. Ranthum. 1969. Distribution of bottom fauna and its utilization by fish in the Fort Madison section of Pool 19, Mississippi River. Ia. Co-op. Fish. Unit Proj. No. 1373. Ames.

Jude, D. J. 1968. Bottom fauna utilization and distribution of 10 species of fish in Pool 19, Mississippi River. Masters Thesis, Iowa State University of Science and Technology, Ames, Iowa. 238 p.

______. 1973. Food and feeding habits of gizzard shad in Pool 19 Mississippi River. Trans. Am. Fish. Soc. 102(2): 378-383.

Keyes, C. R. 1889. An annotated catalogue of the Mollusca of Iowa. Bulletin of the Essex Institute, 20: 1-25.

Marsh, W. A. 1887-1889. Brief notes on the land and fresh-water shells of Mercer Co., Ill. Conchologists' Exchange 1(8): 42-43, 1 (9+10): 50-51, 1(11):62-63, 1(12):74-75, 2(1):4-5, 2(2): 20-21, 2(3): 36-37, 2(4):48-50, 2(5):65-67, 2(6):80-81, 2(7):90-92, 2(8):103-104, 2(9):110-111 Nautilus 3(2):23-24, 3(3):34-35.

Pratt, W. H. 1876. List of the shells at Daveport, Iowa. Proc. Davenport, Acad Nat. Sci. 1 1-165.

Rogers, G. E. 1973. Vertical burrowing abilities of sphaeriid clams in Pool No. 19, Mississippi River. M.S. Thesis, Iowa State University, Ames, IA. 39 pp.

____________. 1976. Vertical burrowing and survival of sphaeriid clams under added substrates in Pool 19, Mississippi River. Iowa St. Journ. Res. 51(1):1-12.

Roy, E. C., Jr. 1963. Checklist of Pleistocene and living Mollusca of Wisconsin. Sterkiana, No. 10: 5-21.

Shimek, B. 1888. The Mollusca of eastern Iowa. Iowa University Natural History Bulletin, 1: 56-81.

Thompson, C. M. and R. E. Sparks. 1977. Status of the fingernail clam. 39th Midwest Fish and Wildlife Conference, Dec. '77 in Madison, WI.

Thompson, D. H. 1969. Feeding behavior of diving ducks on Keokuk Pool, Mississippi River. M.S. Thesis. Iowa St. U. of Sci. and Tech. Ames, Iowa.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

3. Other Molluscs

a. GREAT I

For this topic, all three GREAT Regions will be combined.

Information: The category of Other Molluscs summarizes articles regarding the Asiatic clam *Corbicula fluminea* and freshwater snails in the Upper Mississippi River.

The information concerning *C. fluminea* in the Upper Mississippi River is very sparse. Seventeen articles and reports referring to *C. fluminea* in the Upper Mississippi River were reviewed (Tables 7-9).

Eleven articles and reports referring specifically to freshwater snails in the Upper Mississippi River were compiled and reviewed. However, most general benthic macroinvertebrate surveys of the Upper Mississippi River probably also contain data concerning the snails. This general survey information is discussed in Section D (Benthos) of this report.

Voids: The reports of *Corbicula* in the Upper Mississippi River are primarily concerned with distribution records. There is a dearth of data dealing with research of *Corbicula* life history and the impact of this introduced species on the river ecosystem. Although *Corbicula* has been reported from one end of the Upper Mississippi River to the other, there are several pools in between where this species has not yet been reported. In addition, the method of transportation for the spread of this species has never been positively determined.

Although there are only a few articles concerning snails in the Upper Mississippi River, general benthos surveys would expectedly contain numerous records of snail occurrences. A listing of the snail species of the Upper Mississippi River and their distribution has not been compiled in recent years.

Evaluation: Corbicula fluminea was first reported in the Upper Mississippi River at Cairo, Illinois, in 1964 (Parmalee 1965). Corbicula has since been reported near St. Louis in 1969 (Thomerson and Meyer 1970); at Pool 14 during 1972-1978 (Industrial BIO-TEST Laboratories, Inc. 1973a, 1973b, 1974a, 1974b, 1975a, 1975b, NALCO Environmental Sciences 1976 and 1977; and Lewis 1979); at Pool 9 in 1974 (Eckblad 1975a); in Pool 9, Pool 19 an the St. Crois River during 1977 (Fuller 1978); near Minneapolis, Minnesota, in the Minnesota River during 1978 (Mattice 1978); at Pool 26 and the Lower Stretch of the Upper Mississippi in 1975-1976 (Perry 1979); and at Pools 13 and 15-19 in 1979 (Brice and Lewis 1980, in progress).

Several of these collections were associated with heated discharges (Eckblad 1975, Lewis 1979, Mattice 1979), however, this species is probably ubiquitous in its distribution. The mussel survey by Brice and Lewis (1980, in progress) reported Corbicula to occur commonly at several pools in the U.S. Corps of Engineers' Rock Island District. Although this species has been researched in other areas of the United States, the life history, taxonomy and ecological significance of the Corbicula in the Upper Mississippi has had few studies.

Statewide information regarding snails of the Upper Mississippi River has been obtained from keys, catalogues and lists prepared in Minnesota (Grant 1887 and Dawley 1947), Wisconsin (Baker 1928 and Roy 1963), Iowa (Shimek 1888 and Keyes 1889) and Illinois (Baker 1906). The state species listings and keys for snails are not recent and usually not site-specific but do provide good general information regarding the species composition and distribution of the Upper Mississippi River snails. Site specific data are available from Pool 10 (Baker 1905 and Shimek 1921), Pool 13 (Baker 1903), Pool 16 (Tryon 1865 and

Pratt 1876), Pool 17 (Witter 1978, 1883), and Pools 17-18 (Marsh 1887-1889), however, all this information was collected prior to the present lock and dam system. Many changes would be expected in the snail fauna due to installation of the locks and dams, increased navigation, and further industrialization.

Recommendations: To determine the exact distribution and extent of *Corbicula fluminea*, all future mussel surveys and benthic macroinvertebrate studies in the Upper Mississippii River should include the collecting and reporting of this species. In addition, the Mississippi River populations of *Corbicula* should be researched to gain knowledge of the life history, taxonomy, physiology, environmental requirements, methods of control and ecological impact of this recently introduced species. The clogging capabilities of *Corbicula* in water intakes and power plant condensors, and the potential adverse impact on freshwater mussel beds reveal the need for future research of this pest species.

To obtain a true representation of the present freshwater snail fauna of the Upper Mississippi River, data should be gathered from the recent benthological surveys, reviewed and compared with extant information, when available. These data pertaining to the snail populations could be utilized to assess the impact of historical and future alterations in the Upper Mississippi River as well as to indicate the general water quality conditions of the river.

Literature Cited:

Baker, F. C. 1903. Shell collecting on the Mississippi (Savanna, Illinois). Nautilus 16:102-105.

__________. 1905. The molluscan fauna of McGregor, Iowa. Trans. Acad. Sci. St. Louis. 15:249-256.

__________. 1906. A catalogue of the Mollusca of Illinois. Ill. State Lab. Nat. Hist. Bull. 7(6):53-136.

__________. 1928. The fresh water Mollusca of Wisconsin, Part I, Gastropoda, Bull. Wis. Geol. Nat. Hist. Surv. No. 70. p. 1-309.

Brice, J. R. and R. B. Lewis. 1980, in progress. A survey of selected dredge sites for the presense of freshwater mussels within the Rock Island District of the U.S. Army Corps of Engineers. Prepared by Hazleton Environmental Sciences, Inc.

Dawley, C. 1947. Distribution of aquatic mollusks in Minnesota. Amer. Midl. Nat. 38: 671-497.

Eckblad, J. W. 1975. The Asian clam Corbicula in the Upper Mississippi River. Nautilus. 89(1). 4 p.

Grant, U. S. 1887. Notes on the molluscan fauna of Minnesota. Ann Rept. Geol. and Nat. Hist. Surv. Minn. 16:481-484.

Industrial BIO-TEST Laboratories, Inc. 1973a. M. P. Locke and H. O. Eiler, eds., Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1974a. H. O. Eiler and J. J. Delfino, Eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co., Chigago, IL.

__________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1975a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1975b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (February 1975 through July 1975). Prepared for Commonwealth Edison, Co., Chicago, IL.

Keyes, C. R. 1889. An annotated catalogue of the Mollusca of Iowa. Bulletin of the Essex Institute, 20: 1-25.

Marsh, W. A. 1887-1889. Brief notes on the land and fresh-water shells of Mercer Co., Ill. Conchologists' Exchange 1(8):42-43, 1(9+10: 50-51, 1(11):62-63, 1(12):74-75, 2(1):4-5, 2(2):20-21, 2(3):36-37, 2(4):48-50, 2(5):65-67, 2(6):80-81, 2(7:90-92, 2(8):103-104, 2(9):110-111 . Nautilus 3(2): 23-24, 3(3):34-35.

Mattice, J. S. (ed.) 1978. Corbicula Newsletter. 3(3):2.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1977. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co. Chicago, IL.

Parmalee, P. W. 1965. The Asiatic Clam (Corbicula) in Illinois. Ill. State Acad. Sci. 58(1):39-45.

Perry, E. W. 1979. A survey of Upper Mississippi River mussels. In: Rasmussen, J. L., editor. A compendium of fishery information on the Upper Mississippi River. Second Edition. Upper Mississippi River Conservation Commission, Rock Island, Illinois. pp. 118-139.

Pratt, W. H. 1876. List of shells at Davenport, Iowa. Proc. Davenport Acad. Nat. Sci. 1 1-165.

Roy, E. C., Jr. 1963. Checklist of Pleistocene and living Mollusca of Wisconsin. Sterkiana, No. 10: 5-21.

Shimek, B. 1888. The Mollusca of eastern Iowa. Iowa University Natural History Bulletin, 1: 56-81

__________. 1921. Mollusks of the McGregor, Iowa region I. Iowa Conserv., Vol., No. 4, Oct.-Dec. 5 pp.

Thomerson, J. E. and D. G.Myer. 1970. Corbicula manilensia: range extension upstream in the Mississippi River. Sterkiana 37:29.

Tryon, G. W., Jr. 1865. Catalogue of the Mollusca, collected by Prof. D. S. Sheldon, at Davenport, Iowa. Amer. J. Conch (1):68-70.

Witter, F. M. 1878. List of Mollusca collected at Muscatine, Iowa, U.S.A. Quarterly J. of Conchology pp. 383-394.

__________. 1883. The Mollusca of Muscatine County and vicinity. S. E. Cassino and Co., Boston. 24 pp.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

D. Benthos (Excluding Mollusca)

1. Aquatic Insects

a. GREAT I

Information: Seventy articles and reports describing aquatic insects in the GREAT I region of the Upper Mississippi River were compiled and reviewed (Table 10). The majority of the research was conducted in the headwaters (upstream from Minneapolis - St. Paul) by St. Cloud State University, and in Pool 6 by St. Mary's College and Winona State University. Investigations have been directed toward several aspects of the life history and ecology of the benthic, aufwuchs and drift communities.

Environmental monitoring of power generating stations has been the source of numerous aquatic insect studies in the headwaters of the Upper Mississippi River. The aquatic insect communities in Pool 6 have been researched in detail involving the burrowing mayfly Hexagenia, caddisflies, and general surveys of the drift and the benthic components (Watkins 1969).

Surveys of the aufwuchs communities in Pools 3 and 4 were conducted utilizing artificial substrate samplers. The predominant macroinvertebrates in the aufwuchs communities were the aquatic insects. Benthic macroinvertebrates surveys which also contain aquatic insect data were conducted in Pools 4, 5, 5A, 6, 8, 9 and 10.

Voids: The GREAT I region of the Upper Mississippi River has had numerous investigations of its aquatic insect communities, but most of the research has been concentrated on a limited number of pools. Pools 1, 2, 5A, 5, 7, 8 and 10 have apparently had few or no studies conducted on their aquatic insect assemblages.

Several studies have considered the effects of thermal discharges by power stations on the aquatic insects; however, few studies have researched the effects of other pollutants such as industrial, municipal and non-point source discharges.

Evaluation: Excellent information regarding aquatic insects in the drift, aufwuchs and benthos communities are available from the headwaters of the Mississippi River and Pools 3, 4, 6 and 9. The aquatic insect and general macroinvertebrate survey data collected near power stations in the headwaters of the Upper Mississippi River provide valuable records concerning life history, ecology, distribution, thermal tolerance and density of the insect populations in the drift (Matter 1975, Wefring 1976, Zimmerman 1977) the aufwuchs (Nemanick 1973, Hopwood 1974) and the benthic insect assemblages (McConville 1969, 1972; Northern States Power Co. 1969, 1973a, 1974; Lager 1976; Sarapoo 1977). Much useful information regarding aquatic insects is contained in general macroinvertebrate surveys since aquatic insects are generally a primary component of the drift, aufwuchs and benthos communities.

Additional macroinvertebrate data from the headwaters were obtained by Moyle (1940) in a biological survey from Minneapolis to Crosby, Minnesota and in the intensive life history research of the mayfly *Tricorythodes atratus* in the Mississippi River headwaters (Hall 1975, Hall et al. 1979).

Macroinvertebrates in the aufwuchs communities of Pools 3 and 4 were sampled by Breault and Ulrich (1972), Hoar and Miller (1972), Kaminski (1973) and Simonet (1978) utilizing artificial substrate samplers. These studies provided quantitative and qualitative information concerning the

distribution and ecology of the aufwuchs organisms which were primarily aouatic insects.

The distribution and productivity of the burrowing mayfly Hexagenia has been intensively researched in the GREAT I reach of the Upper Mississippi River by Hemming (1972) in Pool 5A, Erickson (1962, 1964) in Pool 6, and Reis and Wheatley (1978) in Pool 9. The studies of Hexagenia in the Upper Mississippi River by Fremling (1959, 1960b, 1964a, 1964b, 1967, 1968, 1970a, 1970b, 1972, 1973 and 1975) provide additional life history, ecology and control information for this mayfly in the GREAT I region. General research and literature concerning the mayfly Hexagenia in the Upper Mississippi River by Needham (1920) Pasvogel (1962), Jergens (1965), Carlson (1966), Gooch (1967), and Thomford and Fremling (1968) are all pertinent to the entire GREAT I reach of the river.

The caddisflies (Trichoptera) of the GREAT I area have been investigated by Wojcik (1969) in Pool 6 and by Fremling (1959, 1960a) in his research of the entire Upper Mississippi River. These articles contain useful information concerning the biology, control, life history and drift of the caddisflies, especially the family Hydropsychidae.

Additional information regarding aquatic insects in the GREAT I reach of the Upper Mississippi River is found in general benthic macroinvertebrate surveys from Pool 3 (Simonet 1978), Pools 4 through 5A (Skrypek 1966, Northern States Power Co. 1973b), Pool 6 (Surber 1929a, 1929b, 1930 and 1954, and Watkins 1969), Pool 8 (Elstad 1977a, 1977b), Pool 9 (Eckblad 1974, 1975; Eckblad et al. 1977) and Pool 10 (NALCO Environmental Sciences 1974-1975), and drift surveys in Pool 6 (Kodadek 1969, Wood 1969).

Taxonomic keys and other literature regarding the aouatic insect taxa from states bordering the GREAT I reach of the Mississippi River

were obtained from Minnesota (Denning 1937, 1943; Daggy 1941, 1945; Harden and Mickel 1952) and Wisconsin (Hilsenhoff 1970, 1975; Flowers and Hilsenhoff 1975).

Recommendations: The areas in the GREAT I reach of the Upper Mississippi River which have had few or no aquatic insect studies (Pools 1, 2, 5, 5A, 7, 8 and 10) need further investigations to determine the distribution, composition and abundance of the insect communities. Pools 1 and 2, which are reported to be heavily polluted due to the Twin Cities discharges (Fremling 1970b), especially need surveys of the aquatic insect communities to determine the effects of the municipal discharges.

Additional research is needed to determine the effects of agricultural, industrial and municipal inputs, navigation and channel maintenance on aquatic insects. The life history requirements of important taxa such as forage species for fish and ducks, and their trophic relationships need to be defined. This information would be useful in maintaining the health of the aquatic insect community and determining methods of improving the populations. Periodic surveys should be conducted at various locations in the GREAT I region of the Upper Mississippi River to assure that the insects populations are not being degraded.

Literature Cited:

Breault, J. E. and S. D. Ulrich. 1972. Midsummer studies of a year round artificial substrate for macroinvertebrates population in the Upper Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Carlson, C. A. 1966. Effects of three organophosphorus insecticides on immature *Hexagenia* and *Hydropsyche* of the Upper Mississippi River. Trans. Am. Fish Soc. 95(1):1-5.

Daggy, R. H. 1941. Taxonomic and biological investigations on Minnesota mayflies (Ephemeroptera). Ph.D. Thesis, Univ. of Minnesota. 331 pp.

__________. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). Ann. Entomol. Soc. Am. 38:373-396.

Denning, D. G. 1937. The biology of some Minnesota Trichoptera. Trans. Am .Entomol. Soc. 63:17-43.

__________. 1943. The Hydropsychidae of Minnesota (Trichoptera). Entomol. Am. 23:101-171.

Eckblad, J. W. 1974. Preliminary studies on the ecology of Big Lake of Pool 9, Upper Mississippi River. Pap. Pres. at Ann. Mtg. Ia. Acad. Sci., Fayette, IA.

__________. 1975. The benthos and sedimentation rates of a Mississippi River flood plain lake. Pap. Pres. at 23rd Ann. Mtg. N. Am. Benthological Soc., Springfield, Ill., March 20, 1975.

Eckblad, J. W., N. L. Peterson, K. Ostlie, and A. Temte. 1977. The morphometry, benthos and sedimentation rate of a flood plain lake in Pool 9 of the Upper Mississippi River. Am. Midl. Nat. 97(2):433-443.

Elstad, K. 1977a. Macrobenthic survey of navigation Pool 8 of the Upper Mississippi River with special reference to ecological condition. M.S. Thesis, Univ. of Wisconsin, LaCrosse, WI.

__________. 1977b. Benthic macroinvertebrate relationships in navigation Pool 8, Upper Mississippi River 1975. Pap. Pres. at Miss. Riv. Res. Consortium Ann. Mtg., June 8-10, 1977, Winona, MN.

Erickson, J. R. 1962. A comparison of the macrobenthic fauna of four lakes adjacent to the Mississippi River near Winona, Minnesota. M.S. Thesis (in education). Winona State College, Winona, MN. 42 p.

__________. 1964. Three southeastern Minnesota Lakes as possible habitat for *Hexagenia* mayflies. J. Minn. Acad. Sci., Vol. 32, No. 1.

Flowers, R. W. and W. L. Hilsenhoff. 1975. Heptageniidae (Ephemeroptera) of Wisconsin. Great Lakes Ent. 8(4):201-218.

Fremling, C. R. 1959. Biology and possible control of economically important Trichoptera and Ephemeroptera of the Upper Mississippi River. Ph.D. Thesis, Iowa State University, Ames, IA. 205 pp.

__________. 1960a. Biology and possible control of nuisance caddisflies of the Upper Mississippi River. Iowa State Univ. Bull. 483:855-879.

__________. 1960b. Biology of a large mayfly, *Hexagenia bilineata* (Say), of the Upper Mississippi River. Iowa State University Res. Bull. 482:841-852.

__________. 1964a. Rhythmic Hexagenia mayfly emergences and the environmental factors which influence them. Verh. Internat. Verein. Limnol. 15:912-916.

__________. 1964b. Mayfly distribution indicates water quality on the Upper Mississippi River. Science 146(3648):1164-1166.

__________. 1967. Methods for mass-rearing Hexagenia mayflies (Ephemeroptera: Ephemeridae). Trans. Am. Fish. Soc. 96(4):407-410.

__________. 1968. Documentation of a mass emergences of Hexagenia mayflies from the Upper Mississippi River. Trans. Am. Fish. Soc. 97(3):278-280.

__________. 1970a. Factors influencing the distribution of burrowing mayflies along the Mississippi River. Proceeding of First International Conference on Ephemeroptera.

__________. 1970b. Mayfly distribution as a water quality index. Published by EPA - Water Quality Office. 44 pp..

__________. 1972. The impact of man on the ecology of the Mississippi River.

__________. 1973. Environmental synchronization of mass Hexagenia bilineata (Ephemeroptera) emergences from the Mississippi River. Verh. Internat. Verein. Limnol. 18(3):1521-1526.

__________. 1975. Acute toxicity of the lampricide 3-Trifluoromethyl-4-nitrophenol (TEM) to nymphs of mayflies (Hexagenia sp.). U.S. Dept. Int., Fish and Wildlife Service.

Gooch, V. K. 1967. Identification of Hexagenia bilineata and H. limbata nymphs. Entomol. News 78(4):101-103.

Hall, R. J. 1975. Life history, drift, and production of the stream mayfly Tricorythoses atratus McDunnough in the headwaters of the Mississippi River. Ph.D. Thesis, University of Minnesota. 238 pp.

Hall, R. J., T. F. Waters and E. F. Cook. 1979. (In press). The Role of Drift Dispersal in Production Ecology of a Stream Mayfly. Ecology.

Harden, P. H. and C. E. Mickel. 1952. The stoneflies of Minnesota (Plecoptera). Univ. of Minn. Agr. Exp. Sta. Bull. 201:1-84.

Hemming, D. L. 1972. A distribution study of the mayflies, Hexagenia bilineata (Say) and Hexagenia hexagenia limbata (Serville) in the area of Lock and Dam 5A, Winona, Minnesota. M.S. Thesis (education); Winona State College, Winona, MN. 21 pp.

Hilsenhoff, W. L. 1970. Key to genera of Wisconsin Plecoptera (stonefly) nymphs, Ephemeroptera (mayfly) nymphs, Trichoptera (caddisfly) larvae. Wisconsin Department of Natural Resources, Research Report No. 67. 68 pp.

__________. 1975. Aquatic insects of Wisconsin. Wisconsin Department of Natural Resources, Technical Bulletin No. 89, 53 pp.

Hoar, M. A. and Sr. C. Miller. 1972. Midsummer studies of a new year round artificial substrate for macroinvertebrate populations in the Upper Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN.

Hopwood, A. J. 1974. Thermal effects of nuclear power on the Mississippi River at Monticello, Minnesota. Water Resources Research Center, Univ. of Minnesota Graduate School. 131 pp.

Jergens, G. D. 1965. Length-frequency distribution of adult mayflies (Hexagenia) as evidence of a summer generation of the Upper Mississippi River. M.S. Thesis (education). Winona State College, Winona, MN. 30 pp.

Kaminski, C. F., Jr. 1973. The effect of Lock and Dam 3 on macroinvertebrate species diversity on Pool No. 3 in the Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 35 pp.

Kodadek, C. R. 1969. Analysis of prefreeze faunal drift into a slough of the Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 25 pp.

Lager, T. M. 1976. The effect of a thermal discharge on the macroinvertebrates in the Mississippi River near Monticello, Minnesota. Masters Thesis. St. Cloud State University, St. Cloud, MN. 112 pp.

Matter, W. J. 1975. Invertebrate drift in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud State Univesity, St. Cloud, MN. 80 pp.

McConville, D. R. 1969. Macroinvertebrates of the Mississippi River in the Monticello Region. M.S. Thesis. St. Cloud State College, St. Cloud, MN. 85 pp.

__________. 1972. Population dynamics of the macroinvertebrates in the Mississippi River near Monticello, Minnesota. Ph.D. Thesis. University of Minnesota. 197 pp.

Moyle, J. B. 1940. A biological survey of the Upper Mississippi River system. Minn. Dept. Cons., Fish. Res. Unit, Invest. Rept. No. 10.

NALCO Environmental Sciences. 1974-1975. Unpublished monthly progress reports to Wisconsin Public Service Corporation. Power plant site evaluation of the Grant County Site near Glen Haven, Wisconsin.

Needham, J. G. 1920. Burrowing mayflies of our larger lakes and streams. Bull. U.S. Bur. Fish. 36:267-292.

Nemanick, J. M. 1973. Recolonization of macroinvertebrates on artificial substrate samples in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud St. Univ., St. Cloud, MN. 106 pp.

Northern States Power Company. 1969. Environmental monitoring program annual report, Monticello Nuclear Generating Plant. Monticello, MN.

———. 1973a. Monticello Nuclear Generating Plant. Unit 1. Environmental monitoring and ecological studies program. Annual Report 1972. Minneapolis, MN. 576 pp.

———. 1973b. Prairie Island Nuclear Generating Plant. Unit 1 and 2. Environmental monitoring and ecological studies program. Annual Report. 1972. Minneapolis, MN. 754 pp.

———. 1974. Monticello Nuclear Generating Plant. Unit 1. Semiannual operating report No. 7, January - June 1974. Minneapolis, MN. 118 pp.

Pasvogel, C. H. 1962. Factors affecting the variability of Hexagenia bineata (Say) and Hexagenia limbata (Serville) mayfly eggs. Research paper presented to Graduate Council of Winona State College. 55 pp..

Reis, L. and C. Wheatley. 1978. Predicting benthic macroinvertebrate production in backwaters of Pool 9, Mississippi River. B.A. Thesis. Luther College. Decorah, IA. 32 pp.

Sarapoo, W. F. 1977. Production of a stream caddisfly (Hydropsyche phalerata, Hagen) in the Mississippi River near Monticello, MN. M.S. Thesis. St. Cloud Univ., St. Cloud, MN.

Simonet, R. J. 1978. A study on population dynamics of lotic macroinvertebrate community in the lower reaches of Pool 3 of the Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN. 130 pp.

Skrypek, J. 1966. Analysis of physical and biological changes at selected sampling stations in the Mississippi River. Minn. Dept. Cons., Div. of Game and Fish. St. Paul.

Surber, E. W. 1929a. The bottom fauna and plankton as food of the smaller slough fishes in the Upper Mississippi Wildlife and Fish Refuge. M.S. Thesis. Univ. of Minn. 96 pp.

———. 1929b. The utilization of sloughs in the Upper Mississippi Wildlife and Fish Refuge and fish ponds. Trans. Am. Fish. Soc., 59:106-113.

———. 1930. A method of quantitative bottom fauna and facultative plankton study employed in a year's study of slough biology. Trans. Am. Fish. Soc. 60:187-198.

__________. 1954. Bottom fauna survey on three Mississippi River sloughs in Pool 6, May 26-27, 1953. Proc. Ann. Meeting, Upper Mississippi River Conservation Committee, 10:36-39.

Thomforde, L. L. and C. R. Fremling. 1968. Synchronous emergence of Hexagenia bilineata mayflies in the laboratory. Ann. Entomol. Soc. of Am. 61(5):1235-1239.

Watkins, P. 1969. Yearly macroinvertebrate production as relative to organic pollution on Upper Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN. 116 pp.

Wefring, D. R. 1976. Invertebrate drift over a five-day period in the Mississippi River near Becker, Minnesota. M.S. Thesis. St. Cloud State University. St. Cloud, MN. 79 pp.

Wojcik, E. F. 1969. Diurnal periodicity in the drift of Trichoptera larvae in Pool No. 6 of the Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 35 pp.

Wood, N. 1969. Invertebrate drift in the Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN.

Zimmermann, H. J. 1977. Season events in the invertebrate drift in the Mississippi River near Becker, Minnesota. M.S. Thesis. St. Cloud State Univ. St. Cloud, MN. 80 pp.

b. GREAT II

Information: Fifty-nine articles and reports describing aquatic insects in the GREAT II reach of the Upper Mississippi River were compiled and reviewed (Table 11). Several studies centered solely on the mayflies and caddisflies; however, additional information was also available from general surveys addressing all major groups of macroinvertebrates.

The burrowing mayfly Hexagenia has been researched in Pools 19 and 21. These studies of Hexagenia examined the life history, distribution, density, control methods and utilization as forage food. The research by Fremling in the Upper Mississippi River provides additional information concerning Hexagenia in the GREAT II area.

The caddisflies (primarily the family Hydropsychidae) of Pool 19 were investigated by several researchers regarding the biology, control and importance of the organisms as fish food. The only other article dealing specifically with the aquatic insects was a study of the aquatic Diptera in the backwaters of Pool 21.

General macroinvertebrate surveys of this region provide additional information concerning aquatic insects in the GREAT II area. The major macroinvertebrate studies in this reach of the Upper Mississippi River were conducted near industrial and municipal discharges in the Iowa portion of the Mississippi River, near the Quad-Cities Nuclear Station in Pool 14, in Pool 19 by various researchers, and throughout Pools 12-20. Other benthos studies conducted in the GREAT II region include an impact assessment of winter navigation on the benthic macroinvertebrates in Pool 12 and a backwater survey area of Pool 21. Taxonomic and ecological information regarding the aquatic insects in the GREAT II reach of the Mississippi was found in taxonomic keys to Illinois mayflies, stoneflies and caddisflies.

Voids: Investigative efforts have been concentrated on Pool 12-17 and 19-21. Aquatic insects of Pools 11, 13, 18 and 22, however, have received little or no attention. Throughout the GREAT II Region, the effects of point-source discharges and operation and maintenance of the navigation system per insect populations and assemblages have not been adequately addressed.

Evaluation: There is excellent information concerning the aquatic insects of the GREAT II Region of the Upper Mississippi River. A variety of aquatic insect studies have been conducted on the drift, aufwuchs and benthic communities.

Intensive research on the burrowing mayfly *Hexagenia* has been conducted in the GREAT II region by Hoopes (1959, 1960), Fremling (1959, 1960b, 1964a, 1964b, 1967, 1968, 1970a, 1970b, 1972, 1973, 1975), Carlson (1960, 1963, 1968), Carlander (1967), and Dorris and Copeland (1962). The caddisflies, especially Hydropsychidae, have been investigated in the GREAT II area by Fremling (1959, 1960a), Hoopes (1959, 1960), Carlson (1963) and Wenke (1965). The aquatic Diptera were studied in Pool 21 by Dorris (1956). This life history research was the only specific study of the Diptera in the GREAT II reach of Mississippi River.

Valuable information is provided by general surveys of the aquatic macroinvertebrate community. The surveys by the Iowa State Hygienic Laboratory provide excellent data concerning distributional records as well as the effects of several Iowa municipal and industrial discharges on the aquatic macroinvertebrates (Gakstatter and Morris 1969a, 1969b, 1969c, 1969d, 1969e, 1969f, 1970a, 1970b, 1971). Studies near the Quad-Cities Nuclear Station in Pool 14 provide excellent data concerning the drift, aufwuchs and benthos communities of aquatic insects (Beer and Pipes, 1968; Commonwealth Edison Co.

AD-A096 480 HAZLETON ENVIRONMENTAL SCIENCES CORP NORTHBROOK IL F/G 6/6
GREAT RIVER ENVIRONMENTAL ACTION TEAM (GREAT II). LITERATURE RE--ETC(U)
DEC 80 DACW25-79-C-0066
UNCLASSIFIED ES-9057 NL

2 OF 6
AD A
096480

1972, 1975; Industrial BIO-TEST Laboratories, Inc. 1970, 1971, 1972a, 1972b, 1973a, 1973b, 1974a, 1974b, 1975a, 1975b; NALCO Environmental Sciences 1976, 1977; and Lewis 1979). The Federal Water Pollution Control Administration (1969) provided widespread distribution data and information regarding the effects of sewage discharges on aquatic macroinvertebrates at various locations in Pools 12-20. The benthos of Pool 19 has been studied by Jude (1968, 1973) and Gale (1969, 1975). The effects of winter navigation on the benthic macroinvertebrates in Pool 12 was described by Cawley (1978). The backwater surveys by Dorris (1958) in Pool 21 provide additional benthic macroinvertebrate data in the GREAT II region.

Additioral information concerning the aquatic insects in the Mississippi River is found in taxonomic keys to Illinois mayflies (Burke 1953), caddisflies (Ross 1944) and stoneflies (Frison 1935). These important systematic works are applicable to the entire GREAT II Region.

Recommendations: Most areas in the GREAT II reach of the Upper Mississippi River have well described aquatic insect assemblages; however, little or no information is available from Pools 11, 13, 18 and 22. These pools need additional surveys of their aquatic macroinvertebrate communities.

The effects of industrial, municipal and thermal pollution on the aquatic insects have been documented by several studies in the GREAT II reach of the Mississippi River; however, the effects of non-point source discharges, navigation and channel maintenance on aquatic insects have not been adequately researched.

The continued sampling of this stretch of the Mississippi River will serve to monitor the health status of the aquatic insect communities. In addition, the research of the life history requirements and trophic relationships of the important forage species could be utilized to protect and augment the insect fauna in the GREAT II area.

Literature Cited:

Beer, L. P. and W. P. Pipes. 1968. A practical approach to the preservation of the environment, the effects of discharge of condenser water into the Mississippi River. Prepared for Commonwealth Edison Company, Chicago, Illinois, by Environmental Science Division, Chicago and Northwestern Univ.

Burks, B. D. 1953b. The mayflies, or Ephemeroptera, of Illinois. Ill. Nat. Hist. Surv. Bull. 26(1): 1-216.

Carlson, C. A., Jr. 1960. Abundance of Mayfly naiads (Hexagenia spp.) in Pool 19, Upper Mississippi River. M.S. Thesis. Iowa State Univ. of Science and Technology, Ames, IA. 87 pp.

__________. 1963. Bottom fauna of the Mississippi River near Keokuk, Iowa, with paticular reference to possible control of Ephemeroptera and Trichoptera. Unpublished Ph.D. Thesis. Iowa State University of Science and Technology, Ames, Iowa. 199 pp.

__________. 1968. Summer bottom fauna of the Mississippi River above Dam 19, Keokuk, Iowa. Ecology 49(1): 162-169.

Cawley, E. T. 1978. Biological impacts study of winter navigation, Pool 12, Upper Mississippi River. Loras College, Environmental Research Center. Dubuque, Iowa. 14 pp.

Commonwealth Edison Company. 1972. Quad-Cities Station, Units 1 and 2. Determination of Thermal Effects in the Mississippi River, Chicago, IL. 776 pp.

__________. 1975. Three-Sixteen (a&b) Demonstration, Quad-Cities Nuclear Station, Mississippi River. Chicago, IL.

Dorris, T. C. 1956. Limnology of the Middle Mississippi River and adjacent waters. II. Observations on the life histories of some aquatic Diptera. Trans. Ill. State Acad. Sci. 49:27-33.

__________. 1958. Limnology of the Middle Mississippi River and adjacent waters. Lakes on the levied floodplain. Am. Midl. Nat. 59(1): 82-110.

Dorris, T. C. and B. J. Copeland. 1962. Limnology of the Middle Mississippi River. Ill. Mayfly populations in relation to navigation Water-level Control. Limnol. Oceanogr. 7(2): 240-247.

Federal Water Pollution Control Administration. 1969a. Mississippi River reconnaissance, Report of sampling the vicinity of Dubuoue, Iowa, and the tributaries from above Dubuque to below Keokuk, Iowa, in both Iowa annd Illinois. Chicago, Ill. Lake Michigan Basin Office. 169 p.

Fremling, C. R. 1959. Biology and possible control of economically important Trichoptera and Ephemeroptera of the Upper Mississippi River. Ph.D. Thesis, Iowa State University, Ames, IA. 205 p.

__________. 1960a. Biology and possible control of nuisance caddisflies of the Upper Mississippi River. Iowa State Univ. Bull. 483: 855-879.

__________. 1960b. Biology of a large mayfly, Hexagenia bilineata (Say), of the Upper Mississippi River. Iowa State University Res. Bull. 482: 841-852.

__________. 1964a. Rhythmic Hexagenia mayfly emergences and the environmental factors which influence them. Verh. Internat. Verein. Limnol. 15: 912-916.

__________. 1964b. Mayfly distribution indicates water ouality on the Upper Mississippi River. Science 146(3648): 1164-1166.

__________. 1967. Methods for mass-rearing Hexagenia mayflies (Ephemeroptera: Ephemeridae). Trans. Am. Fish. Soc. 96(4): 407-410.

__________. 1968. Documentation of a mass emergence of Hexagenia mayflies from the Upper Mississippi River. Trans. Am. Fish. Soc. 97(3): 278-280.

__________. 1970a. Factors influencing the distribution of burrowing mayflies along the Mississippi River. Proceeding of First International Conference on Ephemeroptera.

__________. 1970b. Mayfly distribution as a water ouality index. Published by EPA - Water Quality Office. 44 p.

__________. 1972. The impact of man on the ecology of the Mississippi River.

__________. 1973. Environmental synchronization of mass Hexagenia bilineata (Ephemeroptera) emergences from the Mississippi River. Verh. Internat. Verein. Limnol. 18(3): 1521-1526.

__________. 1975. Acute toxicity of the lampricide 3-Trifluoromethyl-4-nitrophenol (TEM) to nymphs of mayflies (Hexagenia sp.), U.S. Dept. Int., Fish and Wildlife Service.

Frison, T. H. 1935. The stoneflies, or Plecoptera, of Illinois. Ill. Nat. Hist. Surv. 20(4): 1-471.

Gakstatter, J. H. and R. L. Morris. 1969a. Mississippi River water quality survey report, Clinton, Iowa area. State Hygienic Laboratory Report, University of Iowa.

__________. 1969b. Mississippi River water quality survey report, Fort Madison, Iowa area. State Hygienic Laboratory Report. University of Iowa.

__________. 1969c. Mississippi River water quality survey report, Muscatine, Iowa area. State Hygienic Laboratory Report. University of Iowa.

__________. 1969d. Mississippi River water quality survey report, Davenport, Iowa area. State Hygienic Laboratory Report 70-7. University of Iowa.

__________. 1969e Mississippi River water quality survey report, Keokuk, Iowa area. State Hygienic Laboratory Report 70-8. University of Iowa.

__________. 1969f. Mississippi River water quality survey report, Burlington, Iowa area. State Hygienic Laboratory Report 70-17. University of Iowa.

__________. 1970a. Mississippi River water quality survey report at Burlington, Iowa. State Hygienic Laboratory Report 70-14. University of Iowa.

__________. 1970b. Limnology of the Iowa reach of the Mississippi River. Health Laboratory Service 8: 83-88. Iowa State Hygienic Laboratory Report No. 71-21.

__________. 1971. Water quality survey of the Mississippi River near Dubuque, Iowa. State Hygienic Laboratory Report 72-18. University of Iowa.

Gale, W. F. 1969. Bottom fauna of Pool 19, Mississippi River with emphasis on the life history of the fingernail clam, *Sphaerium transversum*. Ph.D. Thesis. Iowa State University, Ames, IA. 241 p.

__________. 1975. Bottom fauna of a segment of Pool 19, Mississippi River, near Fort Madison, Iowa, 1967-1969. Ia. St. Jour. Res. 49(4 pt. 1): 352-372.

Hoopes, D. T. 1959. Utilization of mayflies and caddisflies by some Mississippi River fishes. Unpublished Masters Thesis. Iowa State University of Sciences and Technology. Ames, IA.

__________. 1960. Utilization of mayflies and caddisflies by some Mississippi River fishes. Trans. Am. Fish. Soc. 89(1): 32-34.

Industrial BIO-TEST Laboratories, Inc. 1970. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1969 through June 1970). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1971. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1970 through December 1970). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1972a. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (April 1971 through December 1971). 3 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1972b. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972) 2 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1973a. M. P. Locke and H. O. Eiler, eds., Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1974a. H. O. Eiler and J. J. Delfino, eds., Operational monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1975a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1975b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (February 1975 through July 1975). Prepared for Commonwealth Edison, Co. Chicago, IL.

Jude, D. J. 1968. Bottom fauna utilization and distribution of 10 species of fish in Pool 19, Mississippi River. Masters Thesis, Iowa State University of Sciences and Technology, Ames, IA. 238 pp.

__________. 1973. Food and feeding habits of gizzard shad in Pool 19 Mississippi River. Trans. Am. Fish. Soc. 102(2): 378-383.

Lewis, R. B. 1979. Benthic macroinvertebrate study. In: C. A. Altstaetter, ed. Environmental monitoring in the Mississippi River near Quad-Cities Station (1968-1978). NALCO Environ. Sci. Rept. to Comm. Ed. Co., Chicago. pp. 61-6.148 + appendix.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1977. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co. Chicago, IL.

Ross, H. H. 1944. The caddisflies, or Trichoptera, of Illinois. Ill. Nat. Hist. Surv. Bull. 23(1): 1-326.

Wenke, T. L. 1965. Some ecological relationships of mayflies, caddisflies and fish in the Mississippi River near Keokuk, Iowa. Ph.D. Thesis, Iowa State Univ. of Science and Technology, Ames, IA.

c. GREAT III

Information: Twenty-seven articles and reports concerning the aquatic insects in the GREAT III reach of the Upper Mississippi River were compiled and reviewed (Table 12). There were no aquatic insect articles which were specific to only the GREAT III area, however, the research on the caddisflies and mayflies in the Upper Mississippi River also pertains to the GREAT III region.

The general macroinvertebrate studies in the GREAT III area also provide information regarding the aquatic insects. Investigations of the drift and benthos communities of Pools 24-26, and the benthos in the Lower Stretch of the Upper Mississippi River were conducted to determine the effects of navigation and channel maintenance on the aquatic macroinvertebrates. The impact of dredge material disposal on benthic macroinvertebrates was evaluated at control and test sites in Pool 25.

Aquatic insect information concerning the GREAT III reach of the Mississippi River was obtained from taxonomic keys for Illinois mayflies, caddisflies and stoneflies. These books supplied data regarding distribution, ecology and taxonomy of species in each order.

Voids: There are no aquatic insect articles which are specific for the GREAT III reach of the Upper Mississippi River, and few articles have general information for this area. There is an absence of data from the GREAT III region which describes the effects of non-point source discharges and various pollutants on the aquatic insect communities.

Evaluation: Although there are no aquatic insect articles which are specific to the GREAT III area of the Upper Mississippi River, there are numerous other sources of information concerning these organisms. The

research of the mayflies and caddisflies in the Upper Mississippi River by Fremling (1959, 1960a, 1960b, 1964a, 1964b, 1967, 1968, 1970a, 1970b, 1972, 1973, 1975) also pertains to the GREAT III Region. In addition, the general macroinvertebrate studies in the GREAT III reach provide information regarding the aquatic insects.

The study by Colbert et al. (1975) inventoried the drift and benthos communities of Pools 24, 25 and 26. The effect of dredge material disposal on benthic macroinvertebrates was evaluated at control and test sites in Pool 25 by Johnson (1976). An inventory of the benthic macroinvertebrates in the Lower Stretch of Upper Mississippi River was conducted by Emge et al. (1974a, 1974b, 1974c) and Johnson et al. (1974). These investigations were concerned with the effects of navigation and channel maintenance on the benthic macroinvertebrates in the GREAT III Region of the Mississippi River.

Other benthic macroinvertebrate data are available from the benthos sampling which has been conducted near the Rush Island Power Station on the Lower Stretch of the Upper Mississippi River (Union Electric Co. 1979). A benthos study to evaluate fish habitat was also performed in the Lower Stretch (Ragland 1974). Additional information concerning the aquatic insects in the GREAT III reach of the Mississippi River is found in taxonomic keys for Illinois mayflies (Burks 1953), caddisflies (Ross 1944) and stoneflies (Frison 1935).

Recommendation: The GREAT III region of the Upper Mississippi River requires extensive baseline survey data on the aquatic macroinvertebrate community, especially the aquatic insects. The degraded Lower Stretch of the Upper Mississippi River should be surveyed initially to determine the current status of the community and to identify the specific causes of the deterioration. Initially, the effects of point and non-point source discharges

and navigation should receive primary attention in these impact analyses. Subsequently the aquatic insects should be monitored at various sites in the GREAT III area to detect any further deterioration or possible improvements in the insect assemblages.

Literature Cited:

Burks, B. D. 1953. The mayflies, or Ephemeroptera, of Illinois. Ill. Nat. Hist. Surv. Bull. 26(1): 216.

Colbert, B. K., J. E. Scott, J. H. Johnson and R. C. Solomon. 1975. Environmental inventory and assessment of navigation pools 24, 25 and 26, Upper Mississippi and Lower Illinois rivers; an aquatic analysis. Army Engineer Waterways Experiment Station, Vicksburg, MS. 368 pp.

Emge, W. P., R. C. Solomon, J. H. Johnson, C. R. Bingham, and B. K. Colbert. 1974a. Physical, bilogical, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. 166 pp.

__________. 1974b. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. 595 p.

__________. 1974c. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. 621 p.

Fremling, C. R. 1959. Biology and possible control of economically important Trichoptera and Epnemeroptera of the Upper Mississippi River. Ph.D. Thesis, Iowa State University, Ames, IA. 205 pp.

__________. 1960a. Biology and possible control of nuisance caddisflies of the Upper Mississippi River. Iowa State Univ. Bull. 483: 855-879.

__________. 1960b. Biology and a large mayfly, Hexagenia bilineata (Say), of the Upper Mississippi River. Iowa State University Res. Bull. 482: 841-852.

__________. 1964a. Rhythmic Hexagenia mayfly emergences and the environmental factors which influence them. Verh. Internat. Verein. Limnol. 15: 912-916.

__________. 1964b. Mayfly distribution indicates water quality on the Upper Mississippi River. Science 146(3648): 1164-1166.

__________. 1967. Methods for mass-rearing Hexagenia mayflies (Ephemeroptera: Ephemeridae). Trans. Am. Fish. Soc. 96(4): 407-410.

__________. 1968. Documentation of a mass emergence of Hexagenia mayflies from the Upper Mississippi River. Trans. Am. Fish. Soc. 97(3): 278-280.

__________. 1970a. Factors influencing the distribution of burrowing mayflies along the Mississippi River. Proceeding of First International Conference of Ephemeroptera.

__________. 1970b. Mayfly distribution as a water quality index. Published by EPA - Water Quality Office. 44 pp.

__________. 1972. The impact of man on the ecology of the Mississippi River.

__________. 1973. Environmental synchronization of mass Hexagenia bilineata (Ephemeroptera) emergences from the Mississippi River. Verh. Internat. Verein. Limnol. 18(3): 1521-1526.

__________. 1975. Acute toxicity of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) to nymphs of mayflies (Hexagenia sp.). U.S. Dept. Int., Fish and Wildlife Service.

Frison, T. H. 1935. The stoneflies, or Plecoptera, of Illinois. Ill. Nat. Hist. Surv. 20(4): 1-471.

Johnson, J. H. 1976. Feasibility of using historic disposal areas, Upper Mississippi River, to evaluate effects of dredged material disposal on community structure of benthic organisms. Army Engineering Waterways Experiment Station, Vicksburg, MS. 90 pp.

Johnson, J. H., R. C. Solomon, C. R. Bingham, B. K. Colbert, and W. P. Emge. 1974. Environmental analysis and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri, and Cairo, Illinois. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 148 pp.

Ragland, D. V. 1974. Evaluation of three side channels and the main channel border of the Middle Mississippi River as fish habitat. Springfield Va. prep. for U.S. Army. Eng. Waterways Experiment Station. AD-786 142.

Ross, H. H. 1944. The caddisflies, or Trichoptera, of Illinois. Ill. Nat. Hist. Surv. Bull 23(1): 1-326.

Union Electric Co. 1979. Rush Island Plant - Demonstration in support of alternate effluent limitation on the thermal discharge. Union Electric Co., St. Louis, MO.

2. Miscellaneous Macroinvertebrates

a. GREAT I

Information: Forty-six articles and reports concerning miscellaneous aquatic macroinvertebrates in the GREAT I reach of the Upper Mississippi River were compiled and reviewed (Table 10). Organisms other than molluscs and insects, such as nematodes, flatworms, bryozoans, oligochaetes, leeches, crustaceans and water mites constitute the miscellaneous macroinvertebrate category. Literature specifically regarding these organisms in the GREAT I area was very sparse.

Studies have been conducted on the drift, food and parasites of the crustacean *Hyalella azteca* in the GREAT I region. Additional knowledge of *Hyalella azteca* and the other miscellaneous macroinvertebrates in the GREAT I region can be obtained from the general macroinvertebrate surveys in this portion of the Mississippi River. These surveys of the drift, aufwuchs and benthos communities contain information concerning the life histories, ecology, pollution tolerances, densities and distribution of the miscellaneous macroinvertebrates in the channel and backwater areas of the Mississippi River.

Voids: There are very few articles from the GREAT I region of the Mississippi River which deal with specific taxa of aquatic macroinvertebrates other than the Mollusca and Insecta. The crustacean *Hyalella azteca* was the only organism which was examined in detail in the GREAT I area. There is, however, additional information on the miscellaneous macroinvertebrates in several general survey reports from this reach of the Mississippi River.

Evaluation: Excellent data concerning the drift (Koehler 1969), food (Mingo 1970) and parasites (Ranstrom 1970, Spirek 1970) of the crustacean *Hyalella azteca* have been collected in the GREAT I Region. Other

valuable information referring to miscellaneous aquatic macroinvertebrates can be found in numerous general macroinvertebrate surveys which have been conducted in the GREAT I reach of the Mississippi River. General macroinvertebrate surveys have been conducted on the drift (Kodadek 1969, Wood 1969, Wefring 1976, Zimmerman 1977), the aufwuchs (Breault and Ulrich 1972, Hoar and Miller 1972, Kaminski 1973, Nemanick 1973, Hopwood 1974, Simonet 1978) and the benthos communities (Surber 1929a, 1929b, 1930, 1954; Moyle 1940; Skrypek 1966; McConville 1969, 1972; Northern States Power Co. 1969, 1973a, 1973b, 1974; Watkins 1969; Eckblad 1974, 1975; NALCO Environmental Sciences 1974-1975; Eckblad et. al. 1977; Elstad 1977a, 1977b; and Sarapoo 1977).

Recommendations: The lack of information concerning the miscellaneous macroinvertebrates in the GREAT I reach of the Mississippi River reveals the need for further investigation of these organisms. Some data regarding miscellaneous macroinvertebrates can be obtained from general macroinvertebrate studies in the GREAT I area, however, little or no survey work has been done in Pools 1, 2, 5, 5A, 7, 8 and 10.

The miscellaneous organisms, such as crustaceans, oligochaetes and leeches, are important forage organisms for fish and ducks. Information is needed concerning life histories, ecology, trophic relationships and distribution of the miscellaneous macroinvertebrates in the GREAT I region and the effects of various pollutants, navigation and channel maintenance on these organisms, especially the ecologically important species. These data can be utilized in monitoring habitat integrity and water quality in the GREAT I area.

Literature Cited:

Breault, J. E. and S. D. Ulrich. 1972. Midsummer studies of a year round artificial substrate for macroinvertebrates population in the Upper Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Eckblad, J. W. 1974. Preliminary studies on the ecology of Big Lake of Pool 9, Upper Mississippi River. Pap. Pres. at Ann Mtg. Ia. Acad. Sci., Fayette, IA.

__________. 1975. The benthos and sedimentation rates of a Mississippi River flood plain lake. Pap. Pres. at 23rd Ann. Mtg. N. Am. Benthological Soc., Springfield, Ill., March 20, 1975.

Eckblad, J. W., N. L. Peterson, K. Ostlie, and A. Temte. 1977. The morphometry, benthos and sedimentation rate of a flood plain lake in Pool 9 of the Upper Mississippi River. Am. Midl. Nat. 997(2): 433-443.

Elstad, K. 1977. Macrobenthic survey of navigation Pool 8 of the Upper Mississippi River with special reference to ecological conditions. M.S. Thesis, Univ. of Wisconsin, LaCrosse, WI.

__________. 1977. Benthic macroinvertebrate relationships in navigation Pool 8, Upper Mississippi River 1975. Pap. Pres. at Miss. Riv. Res. Consortium Ann. Mtg., June 8-10, 1977, Winona, MN.

Hoar, M. A. and Sr. C. Miller. 1972. Midsummer studies of a new year round artificial substrate for macroinvertebrate populations in the Upper Mississippi River. M. S. Thesis, St. Mary's College, Winona, MN.

Hopwood, A. J. 1974. Thermal effects of nuclear power on the Mississippi River at Monticello, Minnesota. Water Resources Research Center, Univ. of Minnesota Graduate School. 131 pp.

Kaminski, C. F., Jr. 1973. The effect of Lock and Dam 3 on macroinvertebrate species diversity on Pool no. 3 in the Mississippi River. B.A. Thesis, St. Mary's College, Winona, MN. 35 pp.

Kodadek, C. R. 1969. Analysis of prefreeze faunal drift into a slough of the Mississippi River. B. A. Thesis, St. Mary's College, Winona, MN. 25 pp.

Koehler, L. W., Jr. 1969. Diurnal periodicity in the drift of Hyalella azteca. B. A. Thesis, St. Mary's College, Winona, MN. 27 pp.

Mingo, R. T. 1970. Food preference of Hyalella azteca within Pool No. 6 of the Mississippi River. M. S. Thesis, St. Mary's College, Winona, MN.

McConville, D. R. 1969. Macroinvertebrates of the Mississippi River in the Monticello Region. M. S. Thesis. St. Cloud State College, St. Cloud, MN. 85 pp.

__________. 1972. Population dynamics of the macroinvertebrates in the Mississippi River near Monticello, Minnesota. Ph.D. Thesis. University of Minnesota. 197 pp.

Moyle, J. B. 1940. A biological survey of the Upper Mississippi River system. Minn. Dept. Cons., Fish. Res. Unit, Invest. Rept. No. 10.

NALCO Environmental Sciences. 1974-1975. Unpublished monthly progress reports to Wisconsin Public Service Corporation. Power plant site evaluation of the Grant County Site near Glen Haven, Wisconsin.

Nemanick, J. M. 1973. Recolonization of macroinvertebrates on artificial substrate samples in the Mississippi River near Monticello, Minnesota. M. S. Thesis, St. Cloud St. Univ., St. Cloud, MN. 106 pp.

Northern States Powr Company. 1969. Environmental monitoring program annual report, Monticello Nuclear Generating Plant. Monticello, MN.

__________. 1973a. Monticello Nuclear Generating Plant. Unit 1. Environmental Monitoring and ecological studies program. Annual Report 1972. Minneapolis, MN. 576 pp.

__________. 1973b. Prairie Island Nuclear Generating Plant. Units 1 and 2. Environmental monitoring and ecological studies program. Annual Report. 1972. Minneapolis, MN. 754 pp.

__________. 1974. Monticello Nuclear Generating Plant. Unit 1, Semi-annual Operating Report No. 7, January - June 1974. Minneapolis, MN. 118 pp.

Ranstrom, C. G. 1970. A survey of acanthocephalic infection in black crappie and amphipod population in Pool No. 6 in the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Sarapoo, W. F. 1977. Production of a stream caddisfly (Hydropsyche phalerata, Hagen) in the Mississippi River near Monticello, MN. M.S. Thesis, St. Cloud Univ., St. Cloud, MN.

Simonet, R. J. 1978. A study on population dynamics of lotic macro-invertebrate community in the lower reaches of Pool 3 of the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN. 130 pp.

Skrypek, J. 1966. Analysis of physical and biological changes at selected sampling stations in the Mississippi River. Minn. Dept. Cons., Div. of Game and Fish. St. Paul.

Spirek, L. J. 1970. The rate and factors influencing the infestation of Hyalella azteca by Acanthocephalan leptorhynncoides thecatus and Polymorphus minutus in Pool No. 5A in the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Surber, E. W. 1929a. The bottom fauna and plankton as food of the smaller slough fishes in the Upper Mississippi Wildlife and Fish Refuge. M.S. Thesis, Univ. of Minn. 96 pp.

__________. 1929b. The utilization of sloughs in the Upper Mississippi Wildlife and Fish Refuge and fish ponds. Trans. Am. Fish Soc., 59:106-113.

__________. 1930. A method of quantitative bottom fauna and facultative plankton study employed in a year's study of slough biology. Trans. Am. Fish. Soc. 60:187-198.

__________. 1954. Bottom fauna survey on three Mississippi River sloughs in Pool 6, May 26-27, 1953. Proc. Ann. Meeting, Upper Mississippi River Conservation Committee, 10:36-39.

Watkins, P. 1963. Yearly macroinvertebrate production as relative to organic pollution on Upper Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN. 116 pp.

Wefring, D. R. 1976. Invertebrate drift over a five-day period in the Mississippi River near Becker, Minnesota. M.S. Thesis, St. Cloud State University. St. Cloud, MN. 79 pp.

Wood, N. 1969. Invertebrate drift in the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Zimmerman, H. J. 1977. Season events in the invertebrate drift in the Mississippi River near Becker, Minnesota. M.S. Thesis, St. Cloud State Univ., St. Cloud, MN. 80 pp.

b. GREAT II

Information: Thirty-four articles and reports concerning miscellaneous macroinvertebrates in the GREAT II region of the Upper Mississippi River were compiled and reviewed (Table 11). Organisms other than the mollusks and insects, such as nematodes, flatworms, bryozoans, oligochaetes, crustaceans and water mites constitute the miscellaneous macroinvertebrates. While there are no studies specifically concerning these organisms, there are numerous general macroinvertebrate surveys which contain information regarding the major components of the aquatic macroinvertebrate community.

Aquatic macroinvertebrate data have been collected in Pools 12, 14, 16, 17, 19 and 20 by the Iowa State Hygienic Laboratory; in the monitoring of Quad-Cities Nuclear Station in Pool 14; in Pools 12-20 by the Water Pollution Control Administration; and in Pool 19 by several researchers. A winter navigation study in Pool 12 and a backwater survey of Pool 21 provide additional information concerning the miscellaneous macroinvertebrates.

Macroinvertebrate studies in other reaches of the Upper Mississippi River which have similar macroinvertebrate faunas are also pertinent to the GREAT II area macroinvertebrates.

Voids: Articles concerning specific taxa of the miscellaneous macroinvertebrates in the GREAT II reach of the Mississippi River were not available. There are much data regarding these organisms which are available from general macroinvertebrate survey reports; however, this information has not been summarized and presented in a separate reference document.

Evaluation: Although there are no detailed articles dealing with specific miscellaneous macroinvertebrate taxa in the GREAT II reach of the

Upper Mississippi River, there is a wealth of general information concerning these organisms in macroinvertebrate surveys.

General benthos studies have been conducted near municipal and industrial discharges in Pools 12, 14, 16, 17, 19, and 20 by the Iowa State Hygienic Laboratory (Gakstatter and Morris 1969a, b, c, d, e, f, 1970a, b, 1971). The influence of these discharges on the macroinvertebrate community was described. Pre- and post-operational monitoring of the Quad-Cities Nuclear Station in Pool 14 provided extremely valuable information concerning the drift, aufuchs and benthos communities (Beer and Pipes 1968; Commonwealth Edison Co. 1972, 1975; Industrial BIO-TEST Laboratories, Inc. 1970, 1971, 1972a,b, 1973a,b, 1974a,b, 1975a,b; NALCO Environmental Sciences 1976, 1977; Lewis 1979). The benthic macroinvertebrates near various sewage discharges in Pools 12-20 of the Mississippi River were surveyed by the Federal Water Pollution Control Administration (1969), which supplied data concerning the effects of these discharges on the macroinvertebrates. Pool 19 has had other benthos surveys performed by Jude (1968, 1973) and Gale (1969, 1975) which investigated the effects of dredging on the benthos and the utilization of macroinvertebrates as fish and duck food. Other areas of aquatic macroinvertebrate research in GREAT II include the winter navigation study of Pool 12 (Cawley 1978) and the backwater surveys of Pool 21 by Dorris (1958).

Recommendations: The void of specific information regarding the miscellaneous macroinvertebrates in the GREAT II reach of the Upper Mississippi River reveals the need for further information concerning these organisms. Much of this information could be obtained from the general macroinvertebrate surveys in this region. Data from the GREAT II region should be compiled and summarized, then utilized to describe the effects of municipal and

industrial discharges on the miscellaneous macroinvertebrates. Monitoring of the miscellaneous macroinvertebrates should be continued periodically at various locations in the GREAT II area to detect any improvement or degradation in the communities and to collect needed life history, ecology and trophic relationship data regarding these organisms. The organisms of particular importance are the crustaceans, oligochaetes and leeches which are valuable food items for fish and ducks. Additional research is needed on the effects of non-point source discharges, navigation and channel maintenance on the miscellaneous macroinvertebrates.

Literature Cited:

Beer, L. P. and W. P. Pipes. 1968. A practical approach to the preservation of the environment, the effects of discharge of condenser water into the Mississippi River. Prepared for Commonwealth Edison Company, Chicago, Illinois, by Environmental Science Division, Chicago and Northwestern Univ.

Cawley, E. T. 1978. Biological impacts study of winter navigation, Pool 12, Upper Mississippi River, Loras College, Environmental Research Center. Dubuque, Iowa. 14 pp.

Commonwealth Edison Company. 1972. Quad-Cities Station, Units 1 and 2. Determination of thermal effects in the Mississippi River. Chicago, IL. 766 pp.

__________. 1975. Three-Sixteen (a & b) Demonstration, Quad-Cities Nuclear Station, Mississippi River. Chicago, IL.

Dorris, T. C. 1958. Limnology of the Middle Mississippi River and adjacent waters. Lakes on the levied floodplain. Am. Midl. Nat. 59(1): 82-110.

Federal Water Pollution Control Administration. 1969a. Mississippi River reconnaissance, report of sampling in the vicinity of Dubuque, Iowa, and the tributaries from above Dubuque to below Keokuk, Iowa, in both Iowa and Illinois. Chicago, IL. Lake Michigan Basin Office. 169 pp.

Gakstatter, J. H. and R. L. Morris. 1969a. Mississippi River water quality survey report, Clinton, Iowa area. State Hygienic Laboratory Report, University of Iowa.

__________. 1969b. Mississippi River water quality survey report, Fort Madison, Iowa area. State Hygienic Laboratory Report. University of Iowa.

__________. 1969c. Mississippi River water quality survey report. Muscatine, Iowa area. State Hygienic Laboratory Report. University of Iowa.

__________. 1969d. Mississippi River water quality survey report, Davenport, Iowa area. State Hygienic Laboratory Report 70-7. University of Iowa.

__________. 1969e. Mississippi River water quality survey report, Keokuk, Iowa area. State Hygienic Laboratory Report 70-8. University of Iowa.

__________. 1969f. Mississippi River water quality survey report, Burlington, Iowa area. State Hygienic Laboratory Report 70-17. University of Iowa.

__________. 1970a. Mississippi River water quality survey report at Burlington, Iowa. State Hygienic Laboratory Report 70-41. University of Iowa.

__________. 1970b. Limnology of the Iowa reach of the Mississippi River. Health Laboratory Service 8: 83-88. Iowa State Hygienic Laboratory Report No. 71-21.

__________. 1971. Water quality survey of the Mississippi River near Dubuque, Iowa. State Hygienic Laboratory Report 71-18. University of Iowa.

Gale, W. F. 1969. Bottom fauna of Pool 19, Mississippi River with emphasis on the life history of the fingernail clam, Sphaerium transversum. Ph.D. Thesis. Iowa State University, Ames, IA. 241 p.

__________. 1975. Bottom fauna of a segment of Pool 19, Mississippi River, near Fort Madison, Iowa, 1967-1969. Ia. St. Jour. Res. 49(4 pt. 1): 352-372.

Industrial BIO-TEST Laboratories, Inc. 1970. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1969 through June 1970). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1971. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1970 through December 1970). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1972a. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (April 1971 through December 1971). 3 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1972b. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972). 2 Vol. Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1973a. M. P. Locke and H. O. Eiler, eds., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1974a. H. O. Eiler and J. J. Defino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1975a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1975b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (August 1974 through January 1975). Prepared for Commonwealth Edison Co. Chicago, IL.

Jude, D. J. 1968. Bottom fauna utilization and distribution of 10 species of fish in Pool 19, Mississippi River. Masters Thesis Iowa State University of Science and Technology, Ames, IA. 238 pp.

__________. 1973. Food and feeding habits of gizzard shad in Pool 19 Mississippi River. Trans. Am. Fish Soc. 102(2): 378-383.

Lewis, R. B. 1979. Benthic macroinvertebrate study. In: C. A. Altstaetter, ed. Environmental monitoring in the Mississippi River near Quad-Cities Station (1968-1978). NALCO Environmental Sciences report to Commonwealth Edison Co., Chicago. pp. 6.1-6.147 and appendix.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co. Chicago, IL.

__________. 1977. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co. Chicago, IL.

c. GREAT III

Information: Eight reports regarding the aquatic macroinvertebrates in the GREAT III Region of the Upper Mississippi River were compiled and reviewed (Table 12). Organisms other than the molluscs and insects, such as nematodes, flatworms, bryozoans, oligochaetes, leeches, crustaceans and water mites constitute the miscellaneous macroinvertebrates. Although there are no specific articles these organisms in the GREAT III Region, general macroinvertebrate surveys usually contain many records of these miscellaneous organisms.

Several general macroinvertebrate studies have been conducted in the GREAT III reach of the Mississippi River which supply valuable information regarding the miscellaneous macroinvertebrates. Macroinvertebrate studies done in this portion of the Mississippi River have concerned the effects of navigation, dredge material disposal, channel maintenance and power plant operation, and an evaluation of fish habitats.

Voids: There are no publications specifically concerning the aquatic macroinvertebrates in the GREAT III Region. Information regarding these organisms can be found in the general macroinvertebrate surveys in the GREAT III area; however, these data have never been summarized into one document.

Evaluation: Although there is no information specifically regarding the miscellaneous macroinvertebrates in the GREAT III Region of the Upper Mississippi River, there have been some valuable data collected concerning these organisms in general macroinvertebrate studies of this area.

Several studies were initiated in the GREAT III area to investigate the effects of channel maintenance on the aquatic macroinvertebrates of the Mississippi River, Colbert et al. (1975) inventoried the drift and

benthos communities of Pools, 24, 25 and 26. The effects of dredge material disposal on benthic macroinvertebrates were evaluated at control and test sites in Pool 25 by Johnson (1976). The benthos in the Lower Stretch of the Upper Mississippi was sampled and described by Emge et al. (1974a, 1974b, 1974c) and Johnson et al. (1974).

Other benthos studies of the Lower Stretch include a benthic macroinvertebrate investigation which was conducted in the side channel and border channel areas to evaluated fish habitats (Ragland 1974) and a benthos sampling conducted to monitor the environmetal impact of the Rush Island Plant in Missouri (Union Electric Co. 1979).

Recommendations: The void of specific data concerning the miscellaneous macroinvertebrates in the GREAT III Region reveals the need for further studies of these organisms. In addition, the miscellaneous organism data found in general macroinvertebrate surveys should be compiled and summarized. This is particularly important for the forage taxa, such as crustaceans, leeches and oligochaetes, which are utilized by fish and ducks for food.

The biologially degraded area in the Lower Stretch of the Upper Mississippi River should be surveyed and researched to determine the reasons for the poor macroinvertebrate fauna and steps which can be taken to improve it.

The effects of pollutants from point and non-point source discharges needs to be investigated. Research data concerning life history requirements and trophic relationships could be utilized to protect or augment the macroinvertebrate community in light of pollution loads. In addition, the aquatic macroinvertebrates should be monitored at various sites in the GREAT III Region to detect any improvements or degradations in the macroinvertebrate communities.

Literature Cited

Colbert, B. K., J. E. Scott, J. H. Johnson and R. C. Solomon. 1975. Environmental inventory and assessment of navigation Pools 24, 25, 26, Upper Mississippi and Lower Illinois rivers; an aquatic analysis. Army Engineer Waterways Experiment Station, Vicksburg, MS. 368 pp.

Emge, W. P., R. C. Solomon, J. H. Johnson, C. R. Bingham, and B. K. Colbert. 1974a. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS.

____________. 1974b. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. 595 pp.

____________. 1974c. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. 621 pp.

Johnson, J. H. 1976. Feasibility of using historic disposal areas, Upper Mississippi River to evaluate effects of dredged material disposal on community structure of benthic organisms. Army Engineer Waterways Experiment Station, Vicksburg, MS. 90 pp.

Johnson, J. H., R. C. Solomon, C. R. Bingham, B. K. Colbert, and W. P. Emge. 1974. Environmental analysis and assessment of the Mississipp River 9 ft channel project between St. Louis, Missouir, and Cairo, Illinois. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 148 pp.

Ragland, D. V. 1974. Evaluation of three side channels and the main channel border of the Middle Mississippi River as fish habitat. Springfield, VA prep. for U.S. Army Enginee Waterways Experiment Station. AD-786. 142 pp.

E. Macrophytes

1. GREAT I

The discussion of macrophytes will be combined for all three GREAT Regions.

Information: Information on the aquatic, semi-aquatic and terrestrial vegetation of the Upper Mississippi River and its floodplain is sparse. A total of 40 articles, both published and unpublished, were compiled and reviewed (Tables 13-15). Reference material was most prevalent for the GREAT I region with only scattered accounts addressing GREAT's II and III.

Of the 40 articles referencing macrophytes, approximately one-half reported macrophyte data only as supportive or descriptive information in conjunction with other topics. Very little historical data were available on macrophytes. Early investigators did little with floral communities. Since 1970, however, increased attention has been given to the importance of macrophyte communities, and many excellent sources have been generated during this time.

Voids: Detailed macrophyte information is lacking for most pools of the Upper Missisisppi River (Tables 13-15). The GREAT I Region has received the greatest attention, particularly Pools 5-9; however, information remains sparse on Pools 1 - 4 and Pool 10. A few excellent studies have been conducted in the GREAT II Region; however, basic detailed pool-specific data are lacking for most of GREAT II. GREAT III has also received only cursory attention regarding aquatic, semi-aquatic and terrestrial macroflora. Only two references of adequate detail and quality were compiled regarding the GREAT III Region.

Each of the GREAT regions appear to be lacking basic survey data. Only scattered pool-specific accounts of species composition, abundance

and distribution are available for the Upper Mississippi River. Furthermore, detailed accounts of habitat requirements for important species appear to be sorely needed, particularly for GREATs II and III. The effects of water level modifications, and river channel alteration upon backwater floral communities have received insufficient attention from researchers, particularly in the GREAT II and III Regions.

Evaluation: Information on macrophytes was compiled from three broad categories of research: 1) Survey studies; 2) Impact studies; and 3) Fish and wildlife related studies.

Survey-type studies of aquatic macrophytes in GREAT I were conducted by Ludescher and Moser (1970) and Mormann (1971). Ludescher and Moser (1970) provide an excellent evaluation of rooted aquatic macrophytes in Lake Winona. Mormann (1971) surveyed wetland and aquatic macroflora to provide baseline data for future comparison and evaluated changes that have occurred over recent years in Pool 5. Two investigators (Smart 1977, Strodthoff 1978) examined the cycling of nitrogen and phosphorus by *Nymphaea tuberosa* and *Ceratophyllum demersum*. Objectives were to determine the exchange of plant nutrients between water, sediment and the macrophytes in Lake Onalaska (Pool 7). Sefton (1976) conducted a detailed survey of aquatic macrophytes in Pool 8 in order to provide basic data on productivity, frequency and distribution. *Ceratophyllum demersum*, *Sagittaria latifolia* and *Vallisneria americana* were the most frequently occurring macrophyte species. In terms of total biomass, predominant taxa (in order of importance) were, *Sagittaria latifolia*, *Vallisneria americana* and *Sagittaria rigida*. This study also examined and compared community composition, production, growth rates and seasonal biomass in two areas typical of the mid and lower reaches of Pool 8.

In the GREAT II and III Regions, surveys were conducted by Evans (1975) and Terpening et al. (1974). Evans (1975) established the occurrence of nine cover types in unprotected floodplain areas. Included was the documentation of 302 species, 13% of which were considered rare, uncommon or endangered elements of the Illinois and Missouri flora. This author also summarized the succession and diversity in floodplain communities. Terpening et al. (1974) examined littoral and terrestrial flora from St. Louis, Missouri to Cairo, Illinois. Assessments of rare or endangered species were made with descriptions of ecological requirements for several species.

Impact studies have been centered primarily in the GREAT I Region, emphasizing the effects of water level fluctuations and alteration of flow characteristics. Olson and Meyer (1976a, 1976b) provided an excellent evaluation of vegetation, land and water surface changes between 1929 and 1973. Principal objectives of these studies were to define impacts associated with U.S. Army Corps of Engineers operation and maintenance of navigable portions of Pools 5 through 10 and the Minnesota and St. Croix Rivers. Similarly, Nielson et al. (1978) examined the effects of Corps flow alterations upon emergent flora in two backwater habitats in the Weaver and Belvidere areas. Comparable studies of flow alterations were conducted in Pools 8 and 9. Swanson (1976) examined habitats influenced by temporary or permanent river inundation in Pool 8. A total of 380 species from 82 families were collected with the largest family (Germinaea) represented by 26 genera and 45 species. Sedge (Carex sp.) was the largest genus with 21 species represented. Ekblad (1973) conducted a study of Pool 9 to assess environmental impacts of U.S. Army Corps of Engineers activities. Included in this analysis was an examination of aquatic and terrestrial plant communities.

In the GREAT II Region, McDonald and Konefes (1977) investigated plant communities and habitats prior to and after construction of the navigational channel and lock and dam system in Pools 11 through 22. Objectives centered on determination of habitat losses and a description of new habitats bordering the pools. Johnson et al. (1974) conducted a similar analysis of the GREAT III Region between St. Louis, Missouri and Cairo, Illinois. This study entailed detailed examination of river morphology and utilized modeling of the river and side channels to predict the effects of river contraction on morphometry and flow characteristics. In addition, inventories of the flora of both the unprotected floodplain and aquatic habitats were compiled to predict the oveall impacts of construction and maintenance on the aquatic and terrestrial habitats.

Several studies of aquatic and terrestrial macroflora have been conducted in conjunction with fish and wildlife concerns. A number of studies have centered on waterfowl. Moyle (1961) examined the relationship of plant types to the production of macroinvertebrates valuable to waterfowl as a food source. Moyle concluded that macrophytes of finely divided leaf types or many branched forms support large numbers of macroinvertebrates that are fed upon heavily by waterfowl and suggested that management of aquatic macrophytes be used to augment waterfowl production. Anderson (1976) correlated the decline in migratory waterfowl to the decline of certain valuable forage species of macrophytes. Limpert (1974) examined the feeding preferences of whistling swans on the upper Mississippi River. This study determined that *Sagittaria latifolia* was a principal forage item in the diet of migrating swans.

Recommendations: Basic survey data are lacking for several pools of the Upper Mississippi River. Continued research, similar to the

investigation by Sefton (1976) will aid in fulfilling voids in baseline information on the system. In addition, further research efforts need to be directed toward impact analysis of river channel contraction upon backwater habitats. Particular attention should be directed toward evaluating the modification or loss of habitat through shunting, dewatering and sedimentation. Emphasis should also be placed upon the identification of unique or ecologically important floral habitats within the Upper Mississippi River. Occurrence of rare, threatened or endangered species should be a basis for these studies as should be the determination of important spawning or nursery areas of fish and production of waterfowl and wildlife.

Literature Cited:

Andersen, M. L. 1976. Causes of decreased migrant waterfowl use in part of the Upper Mississippi River Wildlife and Fish Refuge. M.S. Thesis. Univ. of Wisconsin, Stevens Point. 63 pp.

Eckblad, J. W. 1973. Final report: Environmental impact assessment study, Pool 9, of the northern section of the Upper Mississippi River. N.. Star Res. Inst., Minneapolis, MN.

Evans, D. K. 1975. Characteristics of flora and succession in the Middle Mississippi river floodplain. Proc. W. Va. Acad. Sci. 47(1): 7-13.

Johnson, J. H., R. C. Solomon, C. R. Bingham, B. K. Colbert, and W. P. Emge. 1974. Environmental Analysis and Assessment of the Mississippi River 9-ft. Channel Project Between St. Louis, Missouri, and Cairo, Illinois. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 148 p.

Limpert, R. J. C. 1974. Feeding preferences and behavior of whistling swans on the Upper Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 31 pp.

Ludescher, Fr. K. F. and Br. T. F. Moser. 1970. Survey of aquatic rooted plants in Lake Winona, M.S. Thesis. St. Mary's College, Winona, MN.

McDonald, D. B. and J. L. Konefes. 1977. Pre and post habitat conditions resulting from 9-ft. navigation channel, Upper Mississippi River, Pools 11-22. Univ. of Iowa, Inst. of Hydrol. Res.

Mormann, D. N. 1971. A survey of the species of fish and major forest, marsh, meadow and aquatic flora of a Mississippi River backwater. B.A. Thesis. St. Mary's College, Winona, MN. 37 pp.

Moyle, J. B. 1961. Aquatic invertebrates as related to large water plants and waterfowl. Investigative Report 233. Minn. Dept. Cons. 24 pp.

Nielsen, D. N., C. R. Fremling, R. N. Vose and D. McDonville. 1978. Phase I Study of the Weaver-Belvidere Area, Upper Mississippi River prepared for U.S. Fish and Wildlife Service, St. Paul, MN. Contract #14-16-0003-77-060.

Olson, K. N. and M. P. Meyer. 1976a. Vegetation, land and water surface changes in the upper navigable portion of the Mississippi River Basin over the period 1929-1973. U.S. Army, Corps of Eng. Phase IV, Contr. No. DACW-37-74-C-0043. 19 pp + App. A-G.

___________. 1976b. Vegetation, land and water surface changes in the upper navigable portion of the Mississippi River basin over the period 1939-1973. U.S. Army Corps of Eng. Phase III, Contract No. DACW-37-74-C-0043. 150 pp + App. A-M.

Sefton, D. R. 1976. The biomass and productivity of aquatic macrophytes in nagivation Pool no. 8 of the Upper Mississippi River. M.S. Thesis. Univ. of Wis., LaCrosse, WI. 109 pp.

Smart, M. M. 1977. Nitrogen and phosphorus cycling by *Nymphaea tuberosa* and *Ceratophyllum demersum* in Lake Onalaska navigational pool no. 7 of the Upper Mississippi River. M.S. Thesis. Univ. of Wis., LaCrosse, WI.

Strodthoff, K. M. 1978. Nitrogen and phosphorus exchanges between water, sediment and macrophytes in Lake Onalaska of Pool 7, Upper Mississippi River, 1975 to 1976. M.S. Thesis. Univ. of Wis., La Crosse, WI. 113 pp.

Swanson, S. D. 1976. The vascular flora and phytosociology of navigation Pool 8, the Upper Mississippi River. M.S. Thesis. Univ. of Wis., La Crosse, WI.

Terpening, V. A., L. J. Hunt, D. K. Evans, S. J. Bleiweiss and C. Zoanetti. 1974. A survey of the fauna and flora occurring in the Mississippi Flood Plain between St, Louis, Missouri and Cairo, Illinois. Waterways Experiment Station. U.S. Dept. Army. Contract Y-74-3. 391 pp.

2. GREAT II

See 1. GREAT I.

3. GREAT III

See 1. GREAT 1.

F. Fish

1. Sport Fish

a. Spawning and Reproduction

1) GREAT I

Information: Twenty-eight references were compiled and reviewed on spawning and reproduction of sport fish species in the GREAT I Region (Table 16). Of these, 13 were listed for Pools 8 and 9. For Pools 1 through 7, the number of references listed ranged from 0 to two. Northern pike was the principal species studied in Pool 8 and dealt primarily with spawning activity and habitat. In Pool 9 most information gathered was related to the spawning period and density, fecundity, and factors affecting spawning of catfish. Fragmentary information was also compiled for walleye, sauger, freshwater drum, white sucker, carp, shorthead red horse and shovelnose sturgeon, and was primarily on spawning time and fecundity estimates of these species.

Voids: Little or no information was found on spawning and reproduction of most sport species occurring in the GREAT I Region. This void is most apparent for centrarchid species. Although 12 references were compiled on northern pike and channel catfish (six on each species), the information was limited in scope and restricted primarily to Pools 8 and 9.

Evaluation: Use of the tailwater area of Pool 7 by walleye and sauger for spawning is summarized by Fernholz (1977a) for 1975 and 1976. The condition of mature fish in relation to spawning was noted during the investigations. These species were previously studied in the same area by Gebken and Wright (1972). No spawning concentration of either walleye or sauger was located in the tailwater area in 1970 and 1971. Egg sampling in this area in 1969 recovered walleye eggs but no sauger eggs. Habitats suspected of being used by northern pike for spawning in Pool 8 were investigated by Fernholz

(1976b, 1977c, 1977d) in the spring of 1976 and 1977. Spawning activity was documented by the collection of ripe fish eggs and fry. An earlier study by Finke (1966) reported on the spawning areas of northern pike in Pool 8 near LaCrosse, Wisconsin. Ova production for northern pike sampled from four pools bordering Iowa (Pools 9 and 10 from the GREAT I region) in 1973 and 1975 by Helms (undated) averaged 28,333 eggs per 1 g of body weight. Channel catfish were studied in four pools bordering Iowa in 1972 and 1973 including Pool 9 (Helms 1973, 1974). Fecundity of channel catfish averaged 6359 and 5738 eggs per lb of body weight in those two years with no significant differences among pools noted. Spawning time and intensity was correlated with temperature (Helms 1975). Butler (1951) studied freshwater drum in Pools 3A, 4A, 5A, 6, 9, 10, and 11 from 1946 to 1948 and found that the general spawning time was from May through June.

Recommendations: A scarcity of life history information related to spawning and reproduction of sport fish exists for the GREAT I region. Many of these voids can be adequately filled through the literature, particularly with regard to such aspects as fecundity, spawning temperature and period, incubation time for eggs, and applied to sport fish in the GREAT I region. Although a substantial amount of information on habitat requirements for spawning of these species is available, major habitats used for spawning in the GREAT I region should be well documented and mapped. This information is necessary for proper management and protection of the valuable sport fishing resource in this stretch of the Mississippi River. Some of this information is already available, however a substantial amount can be further acquired by incorporating spawning habitat evaluation into the objectives of regular survey programs conducted in the GREAT I region. Where information voids on or particular species, habitat types or pools are most apparent, special studies

can be conducted to augment the regular survey programs to answer specific questions that require the most attention, particularly where man's activities may impact potentially important spawning habitats. Cooperation and coordination by the various state agencies and other organizations is important so that effort and cost are not duplicated.

Literature Cited:

Butler, R.L. 1951. The age and rate of growth of the sheepshead, *Aplodinotus grunniens* Rafinesque, in the Upper Mississippi River navigation pools. M.S. Thesis, Univ. of Minn. 54 pp.

Fernholz, W. B. 1977a. Five-year summary of boomshocking in the tailwater of Pool 7, Mississippi River. Wis. Dept. Nat. Res., Fish. Div. 1975-1976 Sum. Rept. No. 3. 9 pp.

__________. 1977b. Pool 8 Northern pike spawning study, March 23, 1976-May 11, 1976. Wis. Dept. Nat. Res., Fish Div., 1976-1977. Sum Rept. No. 4. 5 pp.

__________. 1977c. Pool 8 Northern pike spawning study, March 26, 1977 - May 19, 1977. Wis. Dept. Nat. Res., Fish Div., 1976-1977. Sum Rept. No. 5. 4 pp.

__________. 1977d. Fish species captured in fyke nets near Goose Island (River Mile 690-693) during the spring 1977. Wis. Dept. Nat. Res., Fish Div., 1976-1977. Sum. Rept. No. 6. 2 pp.

Finke, A. H. 1906. Northern pike tagging study, Black River, LaCrosse County, Wisconsin. Fish Mngt. Rept. No. 7., Wis. Cons. Dept., Fish Mngt. Div. Madison, WI.

Gebken, D. F. and K. J. Wright. 1972. Walleye and sauger spawning areas study, Pool 7 Mississippi River 1968-1970. Mngt. Rept. No. 60. Wis. Dept. Nat. Res., Bur. Fish. Mngt. 27 pp.

Helms, D. R. 1973. Progress report in the first year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec. Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

__________. 1974. Progress report from the second year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept. 2-178-R-2. Des Moines, IA. 38 pp.

__________. 1975. Variations in the abundance of channel catfish year classes in the Upper Mississippi River and causative factors. Tech. series No. 75-1. Iowa Cons. Comm.

__________. Undated. Progress report on the first year study of northern pike in the Mississippi River. Iowa Cons. Comm.

2) GREAT II

Information: Twenty-two references were compiled and reviewed on spawning and reproduction of three sport fish species in the GREAT II Region (Table 17). Of these, 18 references were listed for Pools 11, 13 and 18. Most references dealt with a long-term investigation of the channel catfish populations in these pools. Information on fecundity, spawning period and factors affecting spawning were gathered. Information on fecundity and spawning period of shovelnose sturgeon was also compiled for Pool 13. Fragmentary information on spawning of freshwater drum was compiled for Pools 11 and 17.

Voids: Little or no information was found on spawning and reproduction of most sport fish species occurring in the Great II Region. This void is most apparent for centrarchid species. Despite the relatively large number of references on channel catfish, the information was mostly general and limited in scope. No references were available specific to Pools 12, 15, 16 and 19-22.

Evaluation: Information on spawning and reproduction of channel catfish was obtained from four Mississippi River pools bordering Iowa in 1972 and 1973, of which Pool 11, 13 and 18 were in the GREAT II Region (Helms 1972a, 1973). No significant differences in fecundity were found among pools, and the number of eggs per lb of body weight of channel catfish averaged 6359 in 1972, and 5738 in 1973. Initial spawning began when the water temperature was 21 C or greater and occurred later in 1973 than in 1972. A study of the life history of shovelnose sturgeon was conducted in four pools bordering Iowa from 1971 through 1973 as part of a more extensive investigation of the species

(Helms 1972, 1973b). Fecundity and general spawning period were evaluated from adult fish collected from Pool 13.

Recommendations: Documentation of major spawning areas of the species in the GREAT II Region should be made to provide the necessary information for proper management and protection of the valuable sport fishing resource in this stretch of the Mississippi River. Valuable information can be acquired by incorporating spawning habitat assessment into the objectives of regular survey programs conducted in the GREAT II Region. In this manner, further studies could be conducted only to augment the general surveys and be limited to specific areas requiring the greatest attention, particularly where man's activities may impact potentially important spawning habitat. Cooperation and coordination among the various governmental agencies and research organizations would keep any duplication of effort and cost to a minimum.

Literature Cited:

Helms, D. R. 1972. Progress report on the first year study of shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Project 2-156-R-1. Iowa Cons. Comm., Des Moines, IA. 22 pp.

__________. 1973a. Progress report on the first year study of sub-legal sized channel catfish in the Mississippi River, Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

__________. 1973b. Progress report in the second year study shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Project 2-156-R-1. Iowa Cons. Comm. 33 pp.

__________. 1974. Progress report on the second year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish Sec., Ann. Prog. Rept. 2-178-R-2. Des Moines, IA. 38 pp.

3) GREAT III

Information: Six references were compiled and reviewed on spawning and reproduction of sport fish in the GREAT III Region (Table 18). Of these, only one reference was specific for a particular pool in the GREAT III Region. Three references provided good reviews and discussions of life history information including the aspects of spawning and reproduction of sport fish species in the Upper Mississippi River. The remaining three references provided general information on spawning of several sport species in the Mississippi River.

Voids: No information was found on spawning and reproduction of sport species that was pool specific for the GREAT III Region. The little information available for the entire GREAT III Region was limited in scope and general in nature.

Evaluation: A brief review of spawning and reproduction characteristics of 16 sport fish species or species groups in the Upper Mississippi River was presented in the UMRCC Fisheries Compendium (Farabee 1979). The data was generally compiled from surveys and research conducted in the Mississippi River; however, other sources were also used. Brief descriptions of the breeding habitats, fecundity and early life history of each species or group is provided, although specific areas of the review from which information was obtained was not referenced. Carlander (1969) provided a thorough review of life history information, including aspects of spawning and reproduction, on North American fish up through the catfish family, and a separate review for the sunfish family (Carlander 1977). Combined, they covered most sport species found in the Upper Mississippi River.

Recommendations: Major spawning habitats of sport fish in the GREAT III Region should be well documented to provide the necessary information for proper management and protection of the valuable sport fishery resource in the GREAT III Region of the Mississippi River. Valuable information can be acquired by incorporating spawning habitat assessment into the objectives of regular survey programs conducted in this stretch of the river. Further evaluations of spawning habitat utilization could be conducted to augment the general surveys and in specific areas requiring special attention, particularly where man's activities may impact potentially important spawning areas. Cooperation and coordination among the various governmental agencies and research organizations would keep any duplication of effort and cost to a minimum.

Literature Cited:

Carlander, D. D. 1969. Handbook of freshwater fishery biology. Vol I. Ia. St. Univ. Press, Ames, IA. 752 pp.

__________. 1977. Handbook of freshwater fishery biology. Vol. II. Life History data on Centrarchid fish. Ia. St. Univ. Press. Ames, IA.

Farabee, G. B. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Contri. of UMRCC. pp 41-68.

b. Age and Growth

1) GREAT I

Information: Forty-two references were compiled and reviewed on age and growth of sport fish in the GREAT I Region (Table 16). The greatest number of references available was for Pool 9; however; several references were compiled for Pools 2, 4, 8 and 10. Age and growth information was compiled for at least 30 sport fishes in the GREAT I Region; the greatest numbers of references were for channel catfish and freshwater drum. Pool 8 contained information on the greatest number of species (20).

Voids: No information on age and growth of sport fish was found for Pools 1, 2 and 5, and for only one species for Pools 5A and 7. For the majority of species, information was limited to a single pool.

Evaluation: Information on age and growth characteristics of freshwater drum was compiled from most pools in the GREAT I Region. Butler (1951) studied drum in six pools in the GREAT I Region from 1936 to 1948 and found that high water and impoundment conditions stimulated increased growth. Growth rates within as well as among pools were similar, and growth was more rapid in these pools than for freshwater drum from Lake Erie (Butler and Smith 1949). Age and growth characteristics of channel catfish were studied in several pools, although most information was from Pool 9. Applegat and Smith (1950) described a method for aging channel catfish collected from Pool 9 in 1945 and 1946 using vertebrae and found that growth is slow throughout life. Schoumacher (1964) reported the growth of channel catfish differed among pools in that growth was greater in Pools 9 and 19 than in most other pools bordering Iowa. Helms (1972) found that channel catfish attained a length of 13 inches (legal length for commercial harvest) late in the second year of life in Pool 9. Age and growth information was obtained for a variety of sport fishes in Pool 8,

including 10 species of suckers (Bur 1976), nine species of sunfish (Wynes 1976) and freshwater drum (Fernholz 1977).

Recommendations: Information on age and growth is necessary in gaining a comprehensive understanding of the sport fish population in the river, as well as enabling proper management decisions to be made relating to the sport fishery. Emphasis should be placed on acquiring information on species of major importance to the sport fishery since these species receive the greatest attention and fishing pressure. Populations may differ substantially from pool to pool; consequently it is advisable that age and growth data be obtained at least for the major sport fishes from all pools in the GREAT I Region.

Literature Cited:

Appleget, J. G. and L. L. Smith, Jr. 1950 The determination of age and growth from vertebrae of the channel catfish, *Ictalurus lacustris lacustris*. Trans. Amer. Fish. Soc. 80: 119-139.

Bur, M. T. 1976. Age, growth and food habits of the Catostomidae in Pool No. 8 of the Upper Mississippi River. M.S. Thesis. Univ. Wis., LaCrosse, WI.

Butler, R. L. 1951. The age and rate of growth of the sheepshead, *Aplodinotus grunniens*, in the Upper Mississippi River navigation pools. M.S. Thesis. Univ. of Minn. 54 pp.

Butler, R. L. and L. L. Smith, Jr. 1949. The age and rate of growth of sheepshead, *Aplodinotus grunniens* (Rafinesque), in the Upper Mississippi River navigational pools. Trans. Amer. Fish. Soc. 79: 43-54.

Fernholz, W. B. 1977. An evaluation of deep water trap nets as commercial gear in Pool 4A (Lake Pepin), Mississippi River. Wis. Dept. Nat. Res., Fish. Sec. Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

Helms, D. R. 1972. Progress report on the first year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

Schoumacher, R. 1964. A brief preliminary report on commercial channel catfish. Iowa Cons. Comm., Quart. Biol. Rept. 16 (1): 10-15.

Wynes, D. 1976. Age, growth and food habits of the Centrarchidae in Pool 8 of the Upper Mississippi River. M.S. Thesis. Univ. Wis., LaCrosse, WI.

2) GREAT II

Information: Fifty-three references were compiled and reviewed on age and growth of sport fish in the GREAT II Region (Table 17). The majority of references were compiled for Pools 11, 13, 14, 18 and the GREAT II Region. Age and growth information was compiled for at least 13 sport fishes, the greatest number of which were for channel catfish. Pool 14 contained information on the greatest number of species (8).

Voids: No information on age and growth of sport fish was found for Pools 20, 21 and 22, and for only one species for Pools 15 and 16. For many of the sport species studied, information was obtained from only a single pool. Although varying amounts of information was compiled on the major sport species in the GREAT II Region, age and growth information on most other sport species in lacking.

Evaluation: Age and growth characteristics of channel catfish were extensively studied in the GREAT II Region. Helms (1967, 1973a, 1974a, 1975) reported on age class abundance and growth of channel catfish in Pools 11, 13 and 18 and made comparisons among years and pools on both topics. Schoumacher (1964a, 1964b, 1965 and 1968) studied the channel catfish from the Mississippi River bordering Iowa and reported on sizes of fish within various age groups. Growth was considered very good although differences among pools were noted. The shovelnose sturgeon was studied in Iowa waters of the Mississippi River from 1971 through 1972 by Helms (1972, 1973b, 1974c). Pool 13 provided most of the information acquired during the study period. Age and growth information was obtained during the studies. Vasey (1965, 1967) studied age and growth characteristics of sauger and walleye in Pool 11 from 1957

through 1959, and again in 1961 and 1962, and found that growth was more rapid for both species than for most other waters, but not as rapid as in new reservoirs. Age and size composition of sport fish collected in Pool 14 near the Quad-Cities Nuclear Station at Cordova, Illinois from 1972 through 1976 were reported by Industrial BIO-TEST Laboratories, Inc. June (1972, 1973a, 1973b, 1974a, 1974b, 1975) and NALCO Environmental Sciences (1976, 1977). Comparisons were made in age class distribution among years and habitats.

Recommendations: An absence of information on age and growth of sport fishes presently exists for several of the pools in the GREAT II Region. Limited information is available on several others. Since this type of information is necessary for proper management decisions to be made regarding the sport fishery, it is recommended that regular survey programs include age and growth assessment of sport fishes in this program. Emphasis should be placed on acquiring information on species of major importance to the sport fishery since these species receive the greatest attention and fishing pressure. Since populations of sport fish may differ substantially among pools, it is advisable that age and growth data be obtained on major sport fishes from all pools in the GREAT II Region.

Literature Cited:

Helms, D. R. 1966. Progress report on the 1977 Mississippi River channel catfish studies. Iowa Cons. Comm., Quart. Biol. Rept. 19(3):46-53

___________. 1972. Progress report on the first year study of shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Project 2-156-R-1. Iowa Cons. Comm., Des Moines, IA. 22 pp.

___________. 1973a. Progress report on the first year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

___________. 1973b. Progress report on the second year shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Project 2-156-R-2. Iowa Cons. Comm. 33 pp.

__________. 1974a. Progress report from the second year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept., 2-178-R-2. Des Moines, IA. 38 pp.

__________. 1974b. Age and Growth of Shovelnose Sturgeon, Scaphirynchus platorynchus (Rafinesque), in the Mississippi River. Iowa State Conservation Commission in Proceeding of Iowa Academy of Science, 81(2): 73-75.

__________. 1974c. Shovelnose sturgeon, Scaphirynchus platorynchus (Rafinesque), in the navigational impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

__________. 1975. Variations in the abundance of channel catfish year classes in the Upper Mississippi River and causative factors. Technical series No. 75-1. Iowa Cons. Comm.

Industrial BIO-TEST Laboratories, Inc. 1972. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972) 2 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1973a. M. P. Locke and H. O. Eiler, eds., Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cites Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1974a. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1975. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co., Chicago, IL.

NALCO Environmental Sciences. 1976. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1977. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

Schoumacher, R. 1964a. Mississippi River catfish investigations in 1963. Part II: small channel catfish and flathead catfish studies. Iowa Cons. Comm., Quart. Biol. Repts. 16(2):42-47.

__________. 1964b. A brief preliminary report on commercial channel catfish. Iowa Cons. Comm., Quart. Biol. Rept. 16(1):10-15.

__________. 1965. Commercial channel catfish catch studies in the Mississippi River in 1964. Iowa Cons. Comm., Quart. Biol. Repts. 17(2): 14-16.

__________. 1968. Some observations on flathead catfish in the Mississippi River bordering Iowa. Trans. Am. Fish. Soc. 97(1):65-66.

Vasey, F. W. 1965. Age and growth of walleye, Stizostedion vitreum (Mitchell), and sauger, Stizostedion candense (Smith), in Pool 11 of the Mississippi River. M.A. Thesis. Iowa State Univ., Ames, IA. 52 pp.

__________. 1967. Age and growth of walleye and sauger in Pool 11 of the Mississippi River. Iowa State J. Sci., 41(4):447-466.

3) GREAT III

Information: Eight references were compiled and reviewed on age and growth of sport fish in the GREAT III Region (Table 18). Of these, four were for the entire Upper Mississippi River in general. Several references provided a review of information on age and growth of sport fishes found in the Upper Mississippi River. The remaining references reported age and growth information on at least nine sport fishes studied in the Lower Stretch of the Upper Mississippi River or the GREAT III Region.

Voids: No information was found on age and growth of sport fishes from Pools 24, 25 and 26 in the GREAT III Region. Most of the age and growth information on sport fishes in the lower stretch of the GREAT III Region was limited to sucker and catfish species.

Evaluation: A brief review of information on age and growth of 16 major sport species or species groups in the Upper Mississippi River is presented by Farabee (1979). The data were generally compiled from surveys and research conducted on the Mississippi River, although other sources were also used. Carlander (1969) provided a comprehensive review of life history information, including aspects of age and growth, on North American fish up through the catfish family and a separate review of the sunfish family (Carlander 1977). Combined, they covered most sport fishes found in the Upper Mississippi River. Robinson (1972, 1973) compared the growth of eight species of fish (river carpsucker, carp, bigmouth buffalo, smallmouth buffalo, channel catfish, flathead catfish, blue catfish and freshwater drum) collected from the Lower Stretch of GREAT III and found there was no one area where fish growth was consistently better than in any other area.

Recommendations: Information on age and growth is necessary in gaining a better understanding of the sport fish population in the river as well as enabling resource managers to make the proper decision related to the sport fishery. Emphasis should be placed on major sport species since they receive the greatest attention and fishing pressure. Populations may differ among pools; consequently, it is advisable that age and growth data be obtained for all pools in the GREAT III Region.

Literature Cited:

Carlander, K. D. 1969. Handbook of freshwater fishing biology. Vol. I. Ia. St. Univ. Press, Ames. 752 pp.

__________. 1977. Handbook of freshwater fishery biology. Vol. II. Life history data on Centrarchid fish. Ia. St. Univ. Press. Ames, IA.

Farabee, G. B. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Contri. of UMRCC. pp. 41-68.

Robinson, J. W. 1972. Population sampling of commercial fish. Final Rept. Mo. Dept. of Cons. D-J Proj. No. 4-3-R-7, work plan No. 21, Job No. 2. 28 pp.

__________. 1973. Research and management of commercial fisheries in Missouri; population sampling of commercial fish in the Mississippi River. Mo. Dept. Cons., Jefferson City. National Marine Fish. Ser. Washington, D.C. 52 pp.

c. Feeding Habits

1) GREAT I

For the discussion of feeding habits of sport fish, all three GREAT regions have been combined.

Information: Twenty-three references were compiled and reviewed on feeding habits of sport fish in the Upper Mississippi River (Tables 16-18). Food habit information was compiled for Pools 1, 3, 4, 5, 5A, 6 and 8 in the GREAT I Region and Pool 14 in the GREAT II Region. No information was compiled for the GREAT III Region. Some sport fish information may be included in Section 4. General Fisheries. Most references were compiled for Pools 6 and 14. A minimum of 24 sport fish species were studied in the GREAT I Region, mostly from Pools 6 and 8, while eight species were studied in Pool 14 in the GREAT II Region.

Voids: Food habit information on sport fish was not found for most pools of the Upper Mississippi River. Most of the information on feeding habits was limited to presentations of food items found in the stomachs of fish. There was little information presented in interspecific competition for food organisms, and the opportunities or selective nature of feeding by sport fishes.

Evaluation: The feeding habits of a variety of sport species have been investigated from the Upper Mississippi River although the most emphasis has been on the major sport species, such as walleye, sauger, crappie, bass and bluegill. Food organisms identified from the stomachs of fish were generally presented as number, frequency of occurrence and volume. Little differences were found in the general selection of food organisms of a species in the various pools studied. Immature insects were the primary food of many of

the sport fish (Comar 1967, Nosek 1976, Pahl and Varchmin 1969, Industrial BIO-TEST Laboratories, Inc. 1972, 1973a), whereas some species fed primarily on fish (Fossum 1975, Pahl and Varchmin 1969, Industrial BIO-TEST Laboratories, Inc. 1973b, 1974a, 1974b). Differences in food selection were generally associated with the availability of food organisms among seasons (May 1975, Pahl and Varchmin 1969) and habitats (Industrial BIO-TEST Laboratories, Inc. 1972, 1973a, 1973b). A brief review of information on feeding habits of 16 major sport species or species groups in the Upper Mississippi River is presented by Farabee (1979). Carlander (1969) provided a comprehensive review of life history information, including aspects of feeding habits, on North American fish up through the catfish family, and a separate review of the sunfish family (Carlander 1977).

Recommendations: Feeding habits and diet of fish are important aspects relating to their life history requirements. Although pool specific information for most sport fish is lacking for the Upper Mississippi River, sufficient information on the general feeding habit requirements of most of these fish is available. However, in areas where man's activities may affect the supply of food organisms of sport fish or where management decisions require specific information on the forage availability, assessment of the forage base and utilization by fish should be made.

Literature Cited:

Carlander, K. D. 1969. Handbook of freshwater fishing biology. Vol. I. Ia. St. Univ. Press, Ames. 752 pp.

__________. 1977. Handbook of freshwater fishing biology. Vol. II. Life history data on Centrachid fish. Ia. St. Univ. Press. Ames, IA.

Comar, R. A. 1969. Food habits of various species of game fish from the Upper Mississippi River Pool 6, with particular reference to the importance of gizzard shad, Dorosoma cepedianum as a forage fish. M.S. Thesis. St. Mary's College. Winona, MN.

Farabee, G. B. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Contri. of UMRCC. pp. 41-68.

Fossum, J. D. 1975. Age and growth, food habit analysis and movement patterns of walleye Stizostedion vitreum vitreum (Mitchell) in Pool Nos. 3 and 4 of the Upper Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN. 144 pp.

Industrial BIO-TEST Laboratories, Inc. 1972. M. P. Locke, ed., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972) 2 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1973a. M. P. Locke and H. O. Eiler, eds., Determination of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1974. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

Mary, K. B. 1975. Food habits of the young-of-the-year smallmouth bass, (Micropterus dolomieui) in a thermal plume in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud St. Univ., St. Cloud, MN. 81 pp.

Nosek, J. A. 1976. Feeding habits of several game fish and rough fish species from the Weaver Bottoms, Half Moon Lake, and Fountain City Bay areas of the Upper Mississippi River. B. A. Thesis. St. Mary's College, Winona, MN.

Pahl, B. P. and T. Varchmin. 1969. A seasonal study of the food habits of five game fish in Pool 6 of the Upper Mississippi River. St. Mary's College, Winona, MN.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

d. Distribution, Movement and Abundance

1) GREAT I

Information: Thirty-one references were compiled and reviewed on distribution, movement and abundance of sport fish in the GREAT I Region (Table 16). Most references were listed for Pools 6 through 10. Distribution, movement and/or abundance of 12 species were reported, with northern pike, walleye and channel catfish receiving the greatest attention. Pool 6 contained information on the greatest number of species.

Voids: Little or no information was available on distribution, movement or abundance of sport fish in Pools 1 through 5A. Although information was available on most major fish species, it was generally limited to a single pool. Many of the sport fish were not mentioned in any of the references reviewed for the GREAT I Region.

Evaluation: The majority of references reviewed for the GREAT I Region dealt with tagging studies conducted to determine the distribution and movement of selected sport fish species in a particular area of the river. Several references also included population estimates for certain species. The remaining references relied on catch data to evaluate distribution and movement of sport fishes. Radiotelemetry was used to determine homing, swimming behavior, range activity patterns and reactions to increased water level on walleye in Pools 7 and 8 (Bahr 1977). Fossum (1975) reported that walleye in Pools 3 and 4 showed no preference for substrate type, but there was some affinity for shoreline areas. Gengerke (1977) tagged 2250 paddlefish in all pools bordering Iowa, mostly in Pool 13, and found that they moved throughout the pool; and some interpool exchange also occurred. Northern pike movement in Pool 8 was investigated by Finke (1966) and Fernholz (1977). Population

estimates were also calculated from tag return data. Larson and Ranthum (1977) studied a congregation of channel catfish in a known winter catfish schooling area in the north end of Pool 7. The time of formation of the congregation was December or January and was estimated at 5300 fish. The spring distribution of five sport fish species was evaluated by Houlihan (1968) in Pool 6 and found that northern pike, largemouth bass, and black crappie inhabit backwaters, while walleye and white bass prefer a tailwater environment. Heise (1969) reported that northern pike, largemouth bass, crappie and walleye were found in backwater areas of Pool 6 in the autumn due to high water level in the river. Seasonal distribution of nine sport fish species were studied by Ostmoe (1967) in Pool 6. Catch data showed that fish were most abundant close to shore at night during the summer, and during the afternoon in fall. Most species tended to migrate out of shallow water areas during fall due to seasonal temperature change.

Recommendations: Information on the distribution, movement and abundance of sport fish has many management applications, both from a resource and recreational standpoint. Sound management decisions for the production of these fishes from man's activities requires a thorough understanding of their distribution, movement and abundance in areas which may be impacted. Although good information is presently available for some species and for certain pools, many voids still exist. An effort should be made to fill these voids. Priority should be placed on gathering information from those pools where it is most lacking, particularly for major sport species, and in specific areas where man's activities may seriously alter the distribution and movement of these fishes.

Literature Cited:

Bahr, D. M. 1977. Homing, swimming behavior, range activity patterns and reactions to increasing water levels of walleyes (*Stizostedion vitreum vitreum*) as determined by radiotelemetry in navigational pool No. 7 and 8 of the Upper Mississippi River during spring 1976. M.S. Thesis. Univ. Wisc., LaCrosse, WI.

Fernholz, W. B. 1977. Pool 8 northern pike spawning study, March 23, 1976-May 11, 1976. Wis. Dept. Nat. Res. Fish Div., 1976-77. Sum. Rept. No. 4. 5 pp.

Finke, A. H. 1966. Northern pike tagging study, Black River, LaCrosse County, Wisconsin. Fish Mngt. Rept. No. 7., Wisc. Cons. Dept. Fish Mngt. Div. Madison, WI.

Fossum, J. D. 1975. Age and growth, food habit analysis and movement patterns of walleyes (Stizostedion vitreum vitreum) (Mitchell) in Pool Nos. 3 and 4 of the Upper Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN. 144 pp.

Gengerke, T. W. 1977. Exploitation, harvest potential and basic life history of paddlefish in the Upper Mississippi River. 39th Midwest Fish and Wildl. Conf., Dec. 1977 in Madison, WI.

Heise, R. A. 1969. Some observations on a autumn sampling of game fish in Pool 6 of Upper Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 28 pp.

Houlihan, J. T., Jr. 1968. The spring distribution and the coefficient of condition of game fish in Pool 6 of the Upper Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 27 pp.

Larson, T. and R. G. Ranthum. 1977. The effects of commercial fishing through the ice on a winter congregation of channel catfish (Ictalurus punctatus) and flathead catfish (Pylodictis olivaris) in Pool 7 of the Mississippi River. Fish Mngt. Rept. No. 99, Wis. Dept. Nat. Res., Bur. Fish. Mngt. Madison, WI.

Ostmoe, R. J. 1967. Abiotic factors, effecting fish distribution in the Upper Mississipi River. B.A. Thesis. St. Mary's College, Winona, MN. 26 pp.

2) GREAT II

Information: Forty-nine references were compiled and reviewed on the distribution and abundance of sport fish in the GREAT II Region (Table 17). Pool 11 provided the largest number of references. Distribution, movement and/or abundance of eight individual sport fish species were reported, with walleye and sauger receiving the greatest attention. Pool 11 contained information on the greatest number of species.

Voids: Little or no information was available on distribution, movement or abundance of sport fish in Pools 12, 20, 21 and 22. Many sport fishes were not mentioned in any of the references reviewed for the GREAT II Region. This void was most apparent for sunfish species. However, some information in Section 4, General Fisheries may include sport fish species.

Evaluation: The majority of references reviewed for the GREAT II Region dealt with tagging studies conducted to determine the distribution and movement of selected sport fish species in particular areas of the river. Several references also included population estimates for certain species, using the Schnabel method. The remaining references relied on catch data to evaluate distribution and abundance of sport fishes. Helms (1972, 1973, 1974) tagged shovelnose sturgeon in most pools bordering Iowa from 1971 through 1973. Population estimates were calculated for the species in Pool 13 in 1971 (estimates generally ranged between 6000 and 7000 fish) and 1973 (averaged 16066 fish). The Iowa Conservation Commission (1978) tagged 2012 paddlefish in pools bordering Iowa, with 1562 being tagged in Pool 13. The estimated population size in the pool was 10,807 fish. Movement to and from the tailwater area of Lock and Dam 12 was estimated to be 10-80% of the pool population. Movement of

walleye and sauger in the GREAT II Region was reported by Cleary (1958a, 1958b, 1960), Hubley (1963) and Schoumacher (1963). Emphasis was placed on Pool 11 and covered a period from 1957 through 1959. Of the 2985 sauger and walleye tagged by Schoumacher (1963) during the three year period, 465 were recaptured. Most recaptured fish were taken within 5 miles of the tagging site. The majority of fish were taken in the home pool, principally in the vicinity of locks and dams.

Recomendations: Information in the distribution, movement and abundance of sport fish species has many management applications, both from a resource and recreational standpoint. Management decisions related to the protection of these fishes from man's activities requires a thorough understanding of their distributions, movement and abundance in areas which may be impacted. Although good information is available for a few sport species in certain pools, many voids still exist. An effort should be made to gather distribution, movement and abundance information from those pools where it is most lacking, particularly for major sport species, and in specific areas where man's activities may seriously alter the distribution, movement or abundance of these fishes.

Literature Cited:

Cleary, R. E. 1958a. Pike tagging program. Progress report on the 1957 pike tagging project on the Mississippi River in vicinity of Guttenberg, Iowa. (Mimeo). UMRCC Proc. 12:161-163.

__________. 1958b. Progress report on walleye and sauger studies in the Mississippi River in Iowa. Iowa Cons. Comm., Quart. Biol. Rept. 10(4):4-5.

__________. 1960. Tagging program: 1959 pike tagging on the Mississippi River at Guttenberg, Iowa, with notes as to 1957 and 1958 recaptures. (mimeo). UMRCC Proc. 16:125-126.

Helms, D. R. 1972. Progress report on the first year study of shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Proj. 2-156-R-1. Iowa Cons. Comm. Des Moines, IA. 22 pp.

____________. 1973. Progress report on the second year study of shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Proj. No. 2-156-R-2. Iowa Cons. Comm. 33 pp.

____________. 1974. Shovelnose sturgeon, *Scaphirynchus platorynchus* (Rafinesque), in the navigational impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

Hubley, R. C., Jr. 1963. The second year of walleye and sauger tagging on the Upper Mississippi River. Wisc. Cons. Dept., West Central Area, Invest. Memo. No. 16. Mimeo., unpublished. 4 pp.

Iowa Conservation Commission. Fisheries Section. 1978. Commercial fisheries investigations; project completion report. Des Moines. 86 pp.

Schoumacher, R. 1963. Results of a walleye and sauger tagging study in the Iowa waters of the Mississippi River. Iowa Cons. Comm., Quart. Biol. Repts. 15(3):14-27.

3) GREAT III

Information: Eleven references were compiled and reviewed on distribution, movement and abundance of sport fish in the GREAT III Region (Table 18). Of these, 10 references were listed for the Upper Mississippi River in general and only one reference referred to the GREAT III Region. Distribution, movement and/or abundance of 5 specific sport fish species were reported, with channel catfish receiving the greatest attention.

Voids: No information was reviewed that dealt with distribution, movement or abundance of sport fishes specific to Pools 24, 25, 26 or the Lower Stretch of the Upper Mississippi River. Most sport fishes were not mentioned in any of the references reviewed for the GREAT III Region. However, information in Section 4. General Fisheries may include some sport fish species.

Evaluation: Carlander (1969) provided a comprehensive review of life history information, including aspects of distribution, movement and abundance, on North American fish up through the catfish family, and a separate review of the sunfish family (Carlander 1977). A summary and brief discussion of the distribution and relating abundance of all 139 species of fish known to occur in the Upper Mississippi River was presented by Rasmussen (1979). The status of each species for each pool is presented following a simple classification scheme. The bulk of data used to compile the summarization table was provided from the work of Smith et al. (1971). Several references dealt with tagging studies of channel catfish and walleye to determine movement patterns of these two species. Christenson (1952) reported on findings and conclusions of a channel catfish study, begun in 1947 under the auspices of the Upper Mississippi

conservation committee and composed of representatives of the five UMRCC state agencies, principally related to movement patterns of the species in the Upper Mississippi River. Some of the findings and conclusions were: considerable general movement occurs in the river but no distinct upstream or downsteam migration is evident; lock and dam installations do not present impossible barriers to the species, initial movement does not appear to be motivated by any spawning instinct; and channel catfish are capable of traveling downstream at a rate of at least three miles per day and have travelled as much as 180 miles in the river.

Recommendations: Information on the distribution, movement and abundance of sport fish has many management applications, both from a resource and recreational standpoint. Management decisions related to the protection of these fishes from man's activities requires a thorough understanding of their distribution, movement and abundance in areas which may be impacted. An absence of this type of information exists in the GREAT III Region. An effort should be made, therefore, to gather this information from the pools within this reach of the river, particularly for major sport species and from particular areas where man's activities may seriously alter the distribution, movement or abundance of these fishes.

Literature Cited:

Carlander, K. D. 1969. Handbook of freshwater fishery biology. Vol. I. Ia. St. Univ. Press. Ames, IA. 752 pp.

__________. 1977. Handbook of freshwater fishery biology. Vol. II. Life history data on Centrarchid fish. Ia St. Univ. Press. Ames, IA.

Christenson, L. M. 1952. Wandering catfish. Wis. Cons. Bull. 17(3): 16-18.

Rasmussen, J. L. 1979. Distribution and abundance of Upper Mississippi River fishes. In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 30-40.

Smith, P. W., A. C. Lopinot and W. L. Pflieger. 1971. A distributional atlas of Upper Mississippi River fishes. Bio. Notes No. 73. Ill. Nat. Hist. Surv. Urbana, IL. 20 pp.

e. Management Techniques

1) GREAT I

Information: One hundred forty-nine references were compiled and reviewed on management techniques for sport fish species in the GREAT I Region (Table 16). Although the majority of Pools contained a relatively large number of references, some of the pools, particularly Pools 1, 2, 3 and 6 contained little information. It should be noted that the information compiled under management techniques was restricted in scope since some of the information on sport fish, which would typically fall under the management category, was reviewed under the other specific subjects.

Voids: Little information was compiled under management techniques for Pools 1, 2, 3 and 6. Only a few references provided good discussions and conclusions on the data as it related to management applications and recommendations on the sport fishing resource in the GREAT I Region.

Evaluation: Much of the basic fishery information that applies to sport fish management was reviewed under other subjects. Most of the references compiled and reviewed under management techniques pertained to information on creel survey statistics, gear evaluation, estimations of mortality and exploitation and fish culturing programs. The majority of references reviewed dealt with reports on creel surveys of various pools in the GREAT I Region. Many of these surveys were conducted at five UMRCC member states. Procedures for conducting the survey program were discussed by the Illinois Conservation Department (1962). More frequent surveys were also conducted by various state agencies in various pools in the GREAT I Region. Some of the surveys were conducted in a single pool while others included several pools of the river. The greatest amount of creel survey information was obtained for

Pool 7. A number of creel surveys extended over a 12 month period, whereas others were restricted to selected seasons of the year, e.g., fall, spring or winter. Some of the surveys were further restricted to tailwater areas and to selected species such as walleye and sauger (Fernholz 1977; Mathson and Wright 1972). Creel survey information typically collected included angler characteristics, fishing pressure, harvest, catch rate, species composition of catch and in some cases length and weights of some fish. Most of the creel survey information compiled covered a period from 1962 through 1978. To assess angler concentration on the Mississippi River, aerial surveys were periodically conducted by various state agencies. This information was applied to planning public access developments, future creel surveys, and determining general river usage by fisherman (Finke and Hubley 1963). The extent of sport fish loss due to commercial gill netting was assessed by Fernholz (1977a, 1977b, 1977c) and Ranthum (1974) in Pools 7 and 8. Northern pike was the major species killed by the nets in both pools; however, netting operations did not appear to adversely affect their populations. Public relations problems resulting from killing these fish were noted, however. Mortality, survival and exploitation rates were available for several sport species in the GREAT I Region. Helms (undated) estimated the annual mortality of northern pike in a study of four pools bordering Iowa, including Pools 9 and 10, to be 68% for male and 66% for female fish. Larson and Ranthum (1977) estimated the annual mortality rate of channel catfish over 12 inches in length to be 48% in Pool 7. Of this, 12% was due to fishing and 36% to natural mortality. Gengerke (1977) calculated the annual survival rate of paddlefish in Pools 9-19 to be 75% for males and 80% for females, whereas the Iowa Conservation Commission (1978) estimated survival in these pools at 63%. The use of northern pike from Pools 10 and 11 as brood

stock for culture operations at the Upper Mississippi River Fishery Management Station at Guttenberg, Iowa was reported by Ackerman (1975, 1979). This species was also obtained from Pool 9 as a source of brood stock for culturing purposes at the Lansing, Iowa hatchery (Spinner 1965).

Recommendations: Creel census statistics along with life history data on sport fishes provides a valuable source of information for assessing the sport fishery as well as gaining a better understanding of the sport fish populations in the GREAT I Region. A greater effort should be expended on obtaining such information in the uppermost pools of the GREAT I Region where it is most lacking. Thorough analysis and evaluation of these data should be made before management recommendation decisions and regulations related to the sport fishery resource in the GREAT I Region are prescribed. These data should be further used to obtain information on exploitation rates, potential yield, productions of future production and response of the fishery to sport fishing regulations.

Literature Cited:

Ackerman, G. L. 1975. 1975 Northern pike culture - Pools 10 and 11 of Mississippi River and Guttenberg Management Station and hatchery. Iowa Cons. Comm. pp. 188-122.

__________. 1976. 1976 Northern pike culture. Mississippi River - Pools 10 and II. Iowa Cons. Comm. Proj. No. 76-II-c-34. pp. 190-195.

Fernholz, W.B. 1977a. Pool 8 gill net monitoring. U.S. Dept. Nat. Res., Fish Div., 1975-76. Sum. Rept. No. 6. pp. 3.

__________. 1977b. Contract gill netting - Pool 7. Wis. Dept. Nat. Res., Fish Div., 1975-76. Sum. Rept. No. 7. pp. 1.

__________. 1977c. Pool 8 gill net monitoring. Wis. Dept. Nat. Res., Fish Div., 1976-77. Sum. Rept. No. 3. pp. 4.

__________. 1977d. Contract gill netting - Pool 7. Wis. Dept. Nat. Res., Fish Div., 1976-77. Sum. Rept. No. 7. pp. 1.

__________. 1977e. Mississippi River fall tailwater sport fishing creel census in Pools 7, 8 and 9 - October 1, 1976 through November 30, 1976. Wis. Dept. Nat. Res., Fish Div., 1976-77. Sum. Rept. No. 10. pp. 13.

Finke, A. H. and R. C. Hubley, Jr. 1963. Concentrations of fisherman on the Mississippi River as defined by aerial census, 1960-1962. Wis. Cons. Dept., West Central Area Invest. Memo, No. 18. Mimeo, unpublished. 29 pp.

Gengerke, T. W. 1977. Exploitation, harvest potential and basic life history of paddlefish in the Upper Mississippi River. 19th Midwest Fish and Wildl. Conf., Dec. 1977 in Madison, WI.

Helms, D. R. (undated). Progress report on the first year study of Northern Pike in the Mississippi River. Iowa St. Cons. Comm.

Illinois Department of Conservation. 1962. 1962 Mississippi River sport fishing creel census procedures. Div. Fish., Springfield. 17 pp. + App.

Iowa State Conservation Commission. Fisheries Section. 1978. Commercial fisheries investigations. Project Completion Report 6. Des Moines. 86 pp.

Larson, T. and R. G. Ranthum. 1977. The effects of commercial fishing through the ice on a winter congregation of channel catfish (Ictalurus punctatus) and flathead catfish (Pylodictis olivaris) in Pool 7 of the Mississippi River. Fish. Mngt. Rept. No. 99. Wis. Dept. Nat. Res., Bur. Fish. Mngt. Madison, WI

Mathson, G. R. and K. J. Wright. 1972. Mississippi River special fall tail-water sport fishing creel census in Pools 7, 8 and 9, October 1, 1971 November 30, 1971. Mngt. Rept. No. 57, Wis. Dept. Nat. Res. Bur. Fish. Mngt. West Central.

Ranthum, R. G. 1974. The effects of a commercial gill net fishery on the fish and waterfowl of Pool 7, Mississippi River. Wis. Dept. Nat. Res., Madison, WI. Bur. Fish and Wildl. Mngt. Nat. Marine Fish. Serv. Wash. D. C. 93 pp.

Spinner, J. P. 1974. Northern pike culture, 1974. Pool 9 of the Mississippi River at Lansing. Iowa Cons. Comm. Proj. No. 74-II-C-84. pp. 154-155.

2) GREAT II

Information: One hundred twenty-four references were compiled and reviewed on management techniques for sport fish species in the GREAT II Region (Table 17). A relatively large number of references were compiled for Pools 11, 13 and 18. The remaining pools contained less information, particularly Pools 19 through 22. It should be noted that information compiled under management techniques was restricted in scope since some of the information on sport fish, which would typically be classified under the management category, was reviewed under the other specific subjects.

Voids: Little information was compiled under management techniques for Pools 19 through 22. Only few references provided good discussions and recommendations on the management applications of the data gathered on the sport fishery in the GREAT II Region.

Evaluation: Much of the basic fishery information that applies to sport fish management was reviewed under other subjects. Most of the references compiled and reviewed under management techniques pertained to creel survey statistics, gear evaluations, estimates of mortality, survival and exploitation and habitat use by anglers. The majority of references reviewed dealt with reports on creel surveys of various pools, particularly Pools 11, 13 and 18. These three pools were selected from the GREAT II Region for conducting intensive creel surveys on the Upper Misissippi River at five year intervals from 1962 to 1973 as part of a cooperative program by the five UMRCC member states. Consequently, most creel census data was compiled from these three pools. A more detailed discussion on the survey design and procedures is provided by the Illinois Conservation Department (1962). Creel survey informa-

tion was obtained for the GREAT II Region for other years and pools, however. Creel surveys typically collected data on angler characteristics, fishing pressure, catch rate, harvest, composition of catch and in some cases lengths and weight of some fish (Kline and Golden, 1979). To assess angler concentrations on the Missssippi River, aerial surveys were periodically conducted by the various states bordering the GREAT II Region. A discussion of the procedures and results of a typical aerial recreational survey is provided by Dunham (1970). The information from the aerial surveys was used for the purpose of planning public access developments, determining future creel survey areas, and assessing general river usage by anglers (Finke and Hubley 1963). Mortality, survival and exploitation rates were available for several sport species in the GREAT II Region. Helms (undated) estimated the annual mortality of northern pike in a study of four pools bordering Iowa, including Pools 13 and 14, to be 68% for male and 66% female fish. Gengerke (1977) calculated the annual survival rate of paddlefish in a study of Pools 9-19 to be 75% for males and 80% for females, whereas the Iowa Conservation Commission (1978) estimated survival of paddlefish in these pools at 63%. Helms (1974) estimated exploitation rates for shovelnose sturgeon, determined from tag returns, to range from 1-43% in the various pools bordering Iowa, but total annual mortality was estimated at nearly 60%. The use of northern pike taken from Pools 10 and 11 as a source of brood stock for culturing operations at the Upper Mississippi River Fishery Management Station at Guttenberg, Iowa is discussed by Ackerman (1975, 1976).

Recommendations: Creel census statistics along with life history data on sport fish provides a valuable source of information for use in assessing the sport fishery, as well as gaining a better understanding of the sport fish populations in the GREAT II Region. A greater effort should be

expended on acquiring this type of information from the lower most pools of the GREAT II Region where it is most lacking. Thorough analysis and evaluation of these data should be made before management recommendations, decisions and regulations related to the sport fishery resource of the GREAT II Region are prescribed.

Literature Cited:

Ackerman, G. L. 1975. 1975 Northern pike culture - Pools 10 and 11 of Mississippi River and Guttenberg Management Station and hatchery. Iowa Cons. Comm. pp. 118-122.

__________. 1976. 1976 Northern pike culture. Mississippi River - Pools 10 and 11. Iowa Cons. Comm. Proj. No. 76-II-c-34. pp. 190-195.

Dunham, L. L. 1970. Aerial recreation survey of the Mississippi River. Ill. Dept. Cons., Div. of Fisheries. 14 pp.

Finke, A. H. and R. C. Hubley, Jr. 1963. Concentrations of fisherman on the Mississippi River as defined by aerial census, 1960-1962. Wis. Cons. Dept., West Central Area Invest. Memo, No. 18. Mimeo, unpublished. 2 pp.

Gengerke, T. W. 1977. Exploitation, harvest potential and basic life history of paddlefish in the Upper Mississippi River. 39th Midwest Fish and Wildl. Conf., Dec. 1977 in Madison, WI.

Helms, D. R. 1974. Shovelnose stugeon, Scaphinrynchus platorynchus (Rafinesque), in the navigational impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

__________. (undated). Progress report on the first year study of northern pike in the Mississippi River. Iowa St. Cons. Comm.

Illinois Department of Conservation. 1962. 1962 Mississippi River sport fishing creel census procedures. Div. Fish., Springfield. 71 pp. + App.

Iowa State Conservation Commission. Fisheries Section. 1978. Commercial fisheries investigations. Project Completion Report. Des Moines. 86 pp.

Kline, D. R. and J. L. Golden. 1979. Analysis of the Upper Mississippi River sport fishery between 1962 and 1973. In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 69-81.

3) GREAT III

Information: Twenty nine references were compiled and reviewed on management techniques for sport fish in the GREAT III Region (Table 18). Most of the references were compiled for the Upper Mississippi River in general. Of the nine references compiled for Pools 24-26, seven were specific to Pool 26. The information compiled under management techniques was restricted in scope since some of the information in sport fish which would generally fall under the subject of management, was reviewed under the other specific subjects.

Voids: Little information was compiled under management techniques for the entire GREAT III Region. Management information for Pools 24, 25 and 26 was limited to creel and aerial surveys of the sport fishery, while no information was compiled for the Lower Stretch of the Upper Mississippi River.

Evaluation: Pool 26 was the only pool selected from the GREAT III Region for conducting intensive creel surveys on the Upper Mississippi at five year intervals from 1962 to 1973 as part of a cooperative program by the five UMRCC member states. Summaries of creel survey statistics for each five year interval (1962-63, 1967-68 and 1972-73) are presented for the seven selected pools in the Upper Mississippi River, including Pool 26, by Fleener (1975), Nord (1964) and Wright (1970). A complete analysis of the Upper Mississippi River sport fishery beteen 1962 and 1973 is presented by Kline and Golden (1979) in the 1979 UMRCC Fisheries Compendium. A thorough analysis is made of the creel survey statistics compiled for all three interval periods as well as a description of the program design and procedures for data collection. A more detailed discussion of the procedures of the program is presented by the

Illinois Department of Conservation (1962). Greenbank (1949) discussed the difficulties of obtaining quantitative estimates of sport fishing pressure and catch for the Upper Mississippi River, while Cleary (1961) compared qualitative and quantitative types of creel surveys and found that a pre-designed procedure of contacting anglers resulted in a 26% reduction in the catch estimate compared to an undisciplined survey. In the late 1950's and early 1960's, prior to the initiation of the cooperative survey program, creel surveys were conducted by the five member states and generally included random angler interviews (Kline and Golden 1979). A comprehensive summary report of a creel census conducted on the Upper Misissippi River during this period is presented by Cleary (1957). During this same time period angler counts were made by airplane to determine the magnitude of total fishing pressure. Results of these aerial surveys are recorded in the UMRCC Proceedings (Upper Mississippi River Conservation Committee 1945-1968). An aerial survey of Pools 12-26 was also conducted in 1970 (Dunham 1970) to assess recreational usage of the Mississippi River bordering Illinois. Results of the survey showed heaviest pleasure craft usage, swimming and water-skiing activity was in Pool 26, although fishing activity was greatest in pools of the GREAT II Region. A discussion and presentation of results of an Upper Mississippi River recreational use survey program initiated in 1973 is presented by Fleener (1979) in the 1979 Fisheries Compendium. This survey utilized a new technique which incorporated a fisheries creel survey into the overall data collection procedures. This study represents the first comprehensive recreational use survey ever conducted on the Mississippi River. This new approach to collecting sport fishery information was adopted by the UMRCC in 1974 for use when collecting future information on recreational use of the Upper Mississippi River and replaced the five-year creel survey program. Successful methods for

culturing buffalo and channel catfish at the Fairport, Iowa Biological Station are reported by Canfield (1918, 1947). Knowledge gained from these studies on culturing procedures has valuable management applications.

Recommendations: Creel census statistics along with life history data provides a valuable source of information for use in making objective decisions in regard to programs that may affect the physical and biological character of the river. This information should be thoroughly evaluated before regulations related to the sport fishery are prescribed. Problems associated with supervision, collection and reporting of creel census data have been noted by Fleener (1975). Although the five-year interval creel survey has been replaced by a comprehensive recreational use survey, the same problems noted by Fleener may continue to exist unless program steps are taken to resolve them.

Literature Cited:

Canfield, H. L. 1918. Methods of collecting and hatching buffalo fish eggs at the U.S. Fisheries Biological Station, Fairport, Iowa. Trans. Amer. Fish. Soc. 47 (3): 85-88.

__________. 1947. Artificial propagation of those channel cats. Prog. Fish. Cult. 9(1): 27-30.

Cleary, R. E. 1957. A summary report on the Mississippi River creel census. In: Supp. Rept. Fish Tech. Sub-Comm., Proc. 13th Ann. UMRCC Mts. pp. II-64.

__________. 1961. Miscellaneous Mississippi River investigations. Iowa Cons. Comm., Quart. Biol. Reps. 13 (2): 1-3.

Dunham, L. L. 1970. Aerial recreation survey of the Mississippi River. IL. Dept. Cons., Div. Fish. 14 pp.

Fleener, G. G. 1975. The 1972-1973 sport fishery survey of the Upper Mississippi River. Contri. UMRCC. 28 pp. + App. A-B.

__________. 1979. Upper Mississippi River recreational use survey (Pool 21). In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 140-158.

Greenbank, J. 1949. A quantitative estimate of sport fishing pressure and catch on the Upper Mississippi River. UMRCC Invest. Rept. No. 37, 25 pp.

Illinois Department of Conservation. 1962. 1962 Mississippi River sport fishing creel census procedures. Div. Fish., Springfield. 17 pp + App.

Kline, D. R. and J. L. Golden. 1979. Analysis of the Upper Mississippi River sport fishery between 1962 and 1973. In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 69-81.

Nord, R. C. 1964. The 1962-1963 sport fishery survey of the Upper Mississippi River. UMRCC. 209 pp.

Upper Mississippi River Conservation Committee. 1945-1968. Proceedings of annual meetings. 4-24 pp. Mimeo.

Wright, K. J. 1970. The 1967-1968 sport fishery survey of the Upper Mississippi River. Contri. UMRCC. 116 pp.

f. Parasites and Diseases

1) GREAT I

For the discussion of parasites and diseases of sport fish, all three GREAT regions have been combined.

Information: Six references were compiled and reviewed on parasites and diseases of sport fish in the Upper Mississippi River (Table 16-18). All six references were listed for the GREAT I Region, of which five were specific for Pool 6. The five references dealt with acanthocephalan or glochidia infection of a variety of sport fish, whereas ectoparasites and digestive tract parasites of several such species were investigated in Pool 1.

Voids: No information was available on parasites and diseases of sport fish in the GREAT II and III Regions. For the GREAT I Region, information was limited primarily to Pool 6 and was specific to a couple of parasites.

Evaluation: Acanthocephalic infection of sport fish species was studied in Pool 6 by Allen (1970), Ranstrom (1970), Spirek (1971) and Zaworski (1970). A total of 10 species were examined in the four separate studies. Results of the study by Allen (1970) indicated that of the six bottom feeding fish examined, only spotted sucker, channel catfish and drum were infected. A total of 10% of the fish examined were infected with acanthocephalans; however, it did not appear to affect the coefficient of condition of these fish. Ranstrom (1970) observed acanthocephalic infection on 80% of the black crappie population, while Spirek (1971) noted infestation of 11% in one year old white bass, 0% in two year old individuals. Evans (1969) investigated the incidence of glochidia infection in walleye, golden redhorse and bluegill and concluded that the rate of infection seems dependent on body size and feeding habits of

the host fish. The ectoparasite and digestive tract parasites infecting three species of fish in Pool 1 were quantitatively and qualitatively determined by Turner (1977). Parasites were found infesting 96% of shorthead redhorse and 90% of white suckers.

Recommendations: The role of parasites and diseases in fish production in natural waters is not well understood. It is generally not considered, however, to be a significant factor in fish populations and ordinarily would not affect the sport fishing in the Upper Mississippi River. It is recommended that regular survey programs carried out by the five UMRCC member states systematically monitor the fish populations of incidence of parasites and disease to serve as a means of early detection of serious infestation in the event that it occurs, and allow for proper decisions to be made regarding public awareness of the problem.

Literature Cited:

Allen, C. W. 1970. Acanthocephalan infestation of various bottom feeding fish in Pool No. 6 of the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Evans, Br. C. 1969. A study of incidence of glochidia infection in redhorse, walleye and bluegill in Pool No. 6, Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Ranstrom, C. G. 1970. A survey of acanthocephalic infection in black crappie and amphipod populations in Pool No. 6 in the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Spirek, J. 1971. Limitation of acanthocephalan infectation of *Roccus chrysops*, Pool No. 6 in the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Turner, W. M. 1977. The ectoparasites and digestive tract parasites infecting three species of catostomidae in the Mississippi River near Becker, Minnesota. M.S. Thesis, St. Cloud Univ., St. Cloud, MN.

Zaworski, S. S. 1970. Winter-spring infestation rates of the acanthocephala *Leptorhynchoides thecatus* in three species of fish in Pool 6 of the Mississippi River. B.A. Thesis, St. Mary's College, Winona, MN. 44pp.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

2. Commercial Fish

a. Spawning and Reproduction

1) GREAT I

For the discussion of spawning and reproduction of commercial fish, all three GREAT regions have been combined.

Information: A total of 38 references were compiled on spawning and reproduction of commercial fishes in the Upper Mississippi River (Tables 19-21). Of these, most were from the GREAT II Region, and Pool 13 was referenced most often. The above references contained pool specific information on seven commercial fish species in the Upper Mississippi River.

Voids: No references were compiled for Pools 2, 7, 8, 12, 14-17, and 19-26, and only one reference was compiled for Pools 1, 3-6, and the Lower Stretch.

Evaluation: Channel catfish were studied in Pools 9, 10, 11, 13 and 18 bordering Iowa in 1972 and 1973 by Helms (1967, 1973a, 1974a, 1975). Fecundity estimates averaged 6359 and 5738 eggs per lb of body weight in those two years with no significant differences among pools shown. Spawning time and intensity was correlated with temperature, although turbidity also influenced spawning. Butler (1951) studied freshwater drum in Pools 3, 4, 5A, 6, 9, 10 and 11 from 1946 to 1948 and found that the general spawning time was from May through June. A study of the life history of shovelnose sturgeon was conducted in pools bordering Iowa from 1971 through 1973, as part of a more extensive investigation of the species (Helms 1972, 1973b, 1974b). An average fecundity of 32,662 eggs per female was estimated from shovelnose sturgeon collected in Pool 13 in 1972. The general spawning period of the species was

also evaluated. Eberley (1975) reported on spawning activities of carp, shorthead redhorse, and white suckers in Pool 1 and presented information on the periods and temperatures when these fish spawned. A brief review of the breeding habits, fecundity and early life history aspects of 16 fish species or species groups in the Upper Mississippi River is presented by Farabee (1979). Of these 16 taxa, eight are represented in the commercial catches. The data were generally compiled from surveys and research conducted on the Mississippi River; however, other sources were also used.

Recommendations: An obvious scarcity of life history information related to spawning and reproduction of commercial fish species exists for the Upper Mississippi River. Although information on habitat requirements for spawning of these species is available in the literature, major habitats used for spawning should be well documented and mapped. This information is necessary for proper management and protection of the valuable commercial fishery resource in the Upper Mississippi River. Some of this information is already available; however a substantial amount can be acquired by incorporating spawning habitat evaluation into the objectives of regular survey programs conducted by the five UMRCC member states. Where information voids on particular species, habitat types or pools are most apparent, special studies could be conducted to augment the regular survey programs to answer specific questions that require the most attention, particularly where man's activities may impact potentially important spawning habitats. Cooperation and coordination by the five state agencies and other research groups is important so that effort and cost are not duplicated.

Literature Cited:

Butler, R. L. 1951. The age and rate of growth of the sheepshead, *Aplodinotus grunniens* Rafinesque, in the Upper Mississippi River navigation pools. M.S. Thesis, Univ. of Minn. 54 pp.

Eberley, L. W. 1975. Spawning activities of major fish species in the Monticello area of the Mississippi River. M.S. Thesis, St. Cloud St. Univ., St. Cloud, MN. 80 pp.

Farabee, G. B. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 41-68.

Helms, D. R. 1967. Progress report on the 1967 Mississippi River channel catfish studies. Iowa Cons. Comm. Quart. Biol. Repts. 19(3): 46-53.

__________. 1972. Progress report on the first year study of shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Proj. 2-156-R-1. Iowa Cons. Comm. Des Moines, IA. 22 pp.

__________. 1973a. Progress report on the first year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Com., Fish. Sec., Ann. Prog. Rept. 2478-F-1. Des Moines, IA. 57 pp.

__________. 1973b. Progress report on the second year shovelnose sturgeon in the Mississippi River. Annual Progress Rept. for project 2-156-R-2. Iowa Cons. Comm. 33 pp.

__________. 1974a. Progress report from the second year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept., 2-178-R-2. Des Moines, IA. 38 pp.

__________. 1974b. Shovenose Sturgeon, *Scaphirynchus platorynchus* (Rafinesque), in the Navigational Impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

__________. 1975. Variations in the Abundance of Channel Catfish Year Classes in the Upper Mississippi River and Causative Factors. Iowa Cons. Comm., Des Moines, IA. 39 pp.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

b. Age and Growth

1) GREAT I

Information: A total of 34 references were compiled on age and growth of commercial fish in GREAT I (Table 19). Of these, 11 were compiled for the entire GREAT I Region and 10 for Pool 9. Age and growth information was presented for 15 species in the GREAT I Region; the greatest number of references were for channel catfish and freshwater drum.

Voids: No references regarding age and growth of commercial fish were compiled for Pools 1, 2, 5 and 7; and only one reference each was made for Pools 3, 5A and 6.

Evaluation: Information on age and growth characteristics of freshwater drum was compiled for most pools in the GREAT I Region. Butler (1951) studied drum in seven pools, of which six were in the GREAT I Region, from 1946 to 1948 and found that high water and impoundment conditions stimulated increased growth. Growth rates within as well as among pools were similar and growth was more rapid in these pools than for freshwater drum from Lake Erie (Butler and Smith 1949). Age and growth of channel catfish were studied in several pools in the GREAT I Region although most information was compiled for Pool 9. Appleget and Smith (1950) described a method for aging channel catfish collected from Pool 9 in 1945 and 1946 using vertebrae and found that growth is slow throughout life. Schoumacher (1964) reports the growth of channel catfish differed among pools in that growth was greater in Pools 9 and 19 than in most other pools bordering Iowa. Helms (1973) found that channel catfish attained a length of 13 inches (legal length for commercial harvest) late in the second year of life in Pool 9.

Recommendations: Age and growth information is important in gaining a comprehensive understanding of commercial fish populations as well as enabling proper management decisions to be made regarding the commercial fishery. Information of this nature is particularly important in prescribing regulations that deal with minimum legal size limits of commercial fishes taken in the harvest. Emphasis should be placed on acquiring information on species of major importance of the commercial fishery since exploitation is greatest among these species. Since populations of commercial fish may differ substantially among pools, it is advisable that age and growth information on major commercial fishes be obtained from all pools in the GREAT I Region.

Literature Cited:

Appleget, S. G. and L. L. Smith, Jr. 1950. The determination of age and growth from vertebrae of the channel catfish, *Ictalurus lacustris lacustris*. Trans. Amer. Fish. Soc. 80:119-139.

Butler, R. L. 1951. The age and rate of growth of the sheepshead, *Aplodinotus grunniens*, in the Upper Mississippi River navigation pools. M.S. Thesis, Univ. of Minn. 54 pp.

Butler, R. L. and L. L. Smith, Jr. 1949. The age and rate of growth of the sheepshead, *Aplodinotus grunniens* (Rafinesque), in the Upper Mississippi River navigational pools. Trans. Amer. Fish. Soc. 79: 43-54.

Helms, D. R. 1973. Progress report on the first year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

Schoumacher, R. 1964. A brief preliminary report on commercial channel catfish. Iowa Cons. Comm., Quart. Biol. Rept. 16(1): 10-15.

2) GREAT II

Information: Forty references were compiled on age and growth of commercial fish in the GREAT II Region (Table 20). The majority of references were compiled for Pools 11, 13 and 18. Age and growth information was presented for five species of which channel catfish received the greatest attention.

Voids: No references regarding age and growth of commercial fish were made for Pools 20-22, and only one reference each was made for Pools 14-16 and 19. Age and growth information was lacking for many of the commercial fish species harvested in the GREAT II Region.

Evaluation: Age and growth characteristics of channel catfish were extensively studied in the GREAT II Region. Helms (1967, 1973, 1974a, 1975) reported on age class abundance and growth of channel catfish in Pools 11, 13 and 18 and made comparisons among years and pools on both topics. Schoumacher (1964a, 1964b, 1965 and 1968) studied the channel catfish from the Mississippi River bordering Iowa and reported on sizes of fish within various age groups. Growth was considered very good although differences among pools were noted. The shovelnose sturgeon was studied in Iowa waters of the Mississippi River from 1971 through 1973 by Helms (1972, 1973b, 1974b, 1974c). Pool 13 provided most of the information acquired during the study period. Age and growth information was obtained from these studies. Gengerke (1977) studied the paddlefish in pools bordering Iowa but concentrated most of his efforts on Pool 13. Aging of 425 paddlefish, using jaw samples, showed collections contained most year classes through age 18. Butler (1951) studied freshwater drum from Pool 11, as well as six pools in the GREAT I Region from 1946 to 1948 and found that

high water and impoundment conditions stimulated increased growth. Butler and Smith (1949) reported on age and growth characteristics of freshwater drum from Pool 17 as well as three pools in the GREAT I Region. Annual growth rates of drum for ages I through III were observed for the period 1939 through 1947, and found more rapid growth from these pools than from drum in Lake Erie.

Recommendations: An absence of information on age and growth of many commercial fishes presently exists for the GREAT II Region. Limited information is available for several species and for most pools. Since this information is important for proper management of the commercial fishery, it is recommended that age and growth information be acquired as part of the regular survey programs conducted in the GREAT II Region. Emphasis should be placed on species of major importance to the commercial fishery since exploitation is greatest among these species.

Literature Cited:

Butler, R. L. 1951. The age and rate of growth of the sheepshead, Aplodinotus grunniens, in the Upper Mississippi River navigation pools. M.S. Thesis, Univ. of Minn. 54 pp.

Butler, R. L. and L. L. Smith, Jr. 1949. The age and rate of growth of the sheepshead, Aplodinotus grunniens (Rafinesque), in the Upper Mississippi River navigational pools. Trans. Amer. Fish. Soc. 79: 43-54.

Gengerke, T. W. 1977. Exploitation, harvest potential and basic life history of the paddlefish in the Upper Mississippi River. 39th Midwest Fish and Wildl. Conf., Dec. 1977 in Madison, WI.

Helms, D. R. 1967. Progress report on the 1967 Mississippi River channel catfish studies. Iowa Cons. Comm. Quart. Reof. Repts. 19(3): 46-3.

____________. 1972. Progress report on the first year study of shovelnose sturgeon in the Mississippi River. Ann. Prog. Rept. for Proj. 2-156-R-1. Iowa Cons. Comm. Des Moines, IA. 22 pp.

____________. 1973a. Progress report on the first year study of sub-legal sized channel catfish in the Mississippi River. Iowa Cons. Comm., Fish See, Ann. Prog. Rept. 2-178-R-1. Des Moines, IA. 57 pp.

__________. 1973b. Progress report on the second year shovelnose sturgeion in the Mississippi River. Annual Progress Rept. 2-156-R-2. Iowa Cons. Comm. 33 pp.

__________. 1974a. Progress report from the second year study of sub-legal sized channel catsifh in the Mississippi River. Iowa Cons. Comm., Fish. Sec., Ann. Prog. Rept., 2-178-R-2. Des Moines, IA. 38 pp.

__________. 1974b. Age and growth of shovelnose sturgeon, Scaphirynchus platorynchus (Rafinesque), in the Mississippi River. Iowa State Conservation Commission in Proceeding of Iowa Academy of Science. 81(2): 73-75.

__________. 1974c. Shovelnose Sturgeon, Scaphirynchus platorynchus (Rafinesque), in the Navigational Impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

__________. 1975. Variations in the abundance of channel catfish year classes in the Upper Mississipi River and causative factors. Iowa Cons. Comm. Des Moines, IA. 39 pp.

Schoumacher, R. 1964a. A brief preliminary report on commercial channel catfish. Iowa Cons. Comm., Quart. Biol. Rept. 16(1): 10-15.

__________. 1964b. A brief preliminary report on commercial channel catfish. Iowa Cons. Comm., Quart. Biol. Rept. 16(1): 10-15.

__________. 1965a. Commercial channel catfish catch studies in the Mississippi River in 1964. Iowa Cons. Comm., Quart. Biol. Repts. 17(2): 14-16.

__________. 1968. Some observations on flathead catfish in the Mississippi River bordering Iowa. Trans. Am. Fish. Soc. 97(1):65-66.

3) GREAT III

<u>Information</u>: Five references were compiled and reveiwed on age and growth of commercial fish in the GREAT III Region and the Upper Mississippi River (Table 21). The two references for the Upper Mississippi River provided a review of information on age and growth of fishes, including commercial species, in the river. The remaining references reported age and growth information on at least nine commercial species from the Lower Stretch of the Upper Mississippi River or the GREAT III Region.

<u>Voids</u>: No information was found on age and growth of commercial fishes specific to the three impounded pools in the GREAT III region. Most of the information from the Lower Stretch of the GREAT III Region was limited to sucker and catfish species.

<u>Evaluation</u>: A brief review of information on 16 species or species groups, including eight commercial fish species, in the Upper Mississippi River is presented by Farabee (1979). The data were generally compiled from surveys and research conducted on the Mississippi River although other sources were also used. Carlander (1969) provided a comprehensive review of life history information, including aspects of age and growth, on North Amercian fishes up through the catfish family. Robinson (1972, 1973) compared the growth of river carpsucker, carp, bigmouth buffalo, smallmouth buffalo, channel catfish, flathead catfish, blue catfish and freshwater drum from the Lower Stretch of the Upper Mississippi River and found there was no one area where fish growth was consistantly better than in any other area.

<u>Recomendations</u>: Information on age and growth is necessary in gaining a better understanding of the sport fish population in the river as well as enabling resource managers to make the proper decision related

to the commercial fishery, particularly when prescribing regulations that deal with minimum size limits of commercial fishes. Emphasis should be placed on major commercial species since exploitation is greatest among these species. Populations may differ among pools; consequently, it is advisable that age and growth data be obtained for all pools in the GREAT III Region.

Literature Cited:

Carlander, K. D. 1969. Handbook of fishwater fishery biology. Vol. I. Ia St. Univ. Press. Ames, IA. 752 pp.

Farabee, G. B. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 41-68.

Robinson, J. W. 1972. Population sampling of commercial fish. Final Rept. Mo. Dept. Cons. D-J Proj. No. 4-3-R-7, Work Plan No. 21, Job No. 2. 28 pp.

__________. 1973. Research and management of commercial fisheries in Missouri, population sampling of commercial fish in the Mississippi River. Mo. Cons. Jefferson City National Marine Fish. Serv., Washington D.C. 52 pp.

c. Feeding Habits

1) GREAT I

For the discussion of feeding habits of commercial fish, all three GREAT regions have been combined.

Information: A total of six references were made regarding the feeding habits of commercial fish in the three GREAT regions and the Upper Mississippi River (Table 19-21). Of these, four concerned the GREAT I Region; one each for Pools 1, 5, 6, and 8. Two references were made which included the entire Upper Mississippi River. Two references, however, presented general, but substantial discussions of fish life history, including food habits of important commercial species of the Upper Mississippi River.

Voids: No references regarding the feeding habits of commercial fish were specific to Pools 2-4, 5A, 7, and 9-26 or the Lower Stretch.

Evaluation: Carlander (1969) presented substantial information about the food habits of freshwater fishes, including many of the important commercial fishes of the Upper Mississippi River although the information is not restricted to that area. Farabee (1979), however, summarized the life history information, including feeding habits of the important sport and commercial fishes of the Upper Mississipi River. Several references present information on the feeding habits of some commercial fish species of the Upper Mississippi River. Anderson (1972) studied the food habits and diurnal and seasonal feeding periodicity of shorthead redhorse and carp, while Bur (1976) examined the food habits of catostomids in different habitats. Comar (1967) found that channel catfish utilized mayflies rather than gizzard shad, and Nosek (1976) reported that rough fish fed on invertebrates.

Recommendations: Probably extensive studies of commercial fish feeding habits need not be performed. It is recommended, however, that a greater understanding of the food habits and feeding ecology of commercial fishes would be useful for a better understanding of the community relationships.

Literature Cited

Anderson, R. 1972. Food habits, length weight relations, and conditions of the shorthead redhorse (Moxostoma macrolepidoteum Lesueur) and the carp (Cyprinus Carpoi L.) collected from the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud Univ., St. Cloud, MN. 111 pp.

Bur, M. 1976. Age, growth and food habits of the catostomidae in Pool No. 8 of the Upper Mississippi River. M.S. Thesis. Univ. Wis., La Crosse, WI.

Carlander, K. D. 1969. Handbook of fishwater fishery biology. Vol. I. Ia St. Univ. Press. Ames, IA. 752 pp.

Comar, R. 1967. Food habits of various species of game fish from the Upper Mississippi River Pool 6 with particular reference to the importance of gizzard shad, Dorosoma cepedianum, as a forage fish. M.S. Thesis. St. Mary's College, Winona, MN.

Farabee, G. B. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Contri. UMRCC. pp. 41-68.

Nosek, J. 1976. Feeding habits of several game fish and rough fish species from Weaver Bottoms, Half Moon Lake, and Fountain City Bay Areas of the Upper Mississippi River. B.A. Thesis. St. Mary's College. Winona, MN.

d. Distribution, Movement, and Abundance

1) GREAT I

Information: A total of 18 references were made regarding the distribution, movement and abundance of commercial fish in the GREAT I Region (Table 19). Of these, six were concerned with the entire GREAT I Region, and seven were for Pools 9. These references largely report results of studies on shovelnose sturgeon, paddlefish and channel catfish.

Voids: No references regarding distribution, movement, and abundance of commercial fish were made for Pools 1-3, 5, 5A, or 8. Aside from studies of shovelnose sturgeon, paddlefish and channel catfish, the distribution, movement, and abundance of few commercial species have been studied.

Evaluation: Channel catfish is, perhaps, the most widely studied commercial fish species in GREAT I. Probably, this results because it is also readily accepted by sport fishermen. Hubley (1961, 1963), Satek (1948), and Ranthum (1971) reported various channel catfish tagging and movement studies and usually included discussions regarding the relative abundance and harvest of channel catfish. Ranthum (1974) and Larson and Ranthum (1977) discussed the effects of commercial fishing on catfish in Pool 7 during winter. At that time, the catfish are concentrated and particularly vulnerable to overfishing.

Helms (974) presented the last of a series of reports on the shovelnose sturgeon in Iowa waters of the Mississippi River in which his discussions included results of population studies, tagging and movement studies, distribution of commercial harvest, and exploitation rates. Paddlefish also received special attention. Gengerke (1977) and Iowa Conservation Commission (1978) studied the paddlefish in Iowa waters of the Mississippi. They reported

the results of an extensive tagging and movement study and discussed the commercial harvest at various locations and estimated the population size.

Aside from the studies, Cleary (1958) summarized two years of a fisheries survey and reported that the ratio of weights of game to commercial species in the Iowa-Wisconsin section of the river (Pools 8-11) was 45:48.

Recommendations: Information on the distribution, movement, and abundance of commercial fishes is essential to an effective management program. It is recommended, therefore, that more studies be performed to investigate these important aspects of fish life history. Special emphasis should be placed on those species which are currently poorly studied, but which are important in the commercial fishery, as well as those Pools which previously have received little attention.

Literature Cited:

Cleary, R. 1958. Summaries of the 1956 and 1957 exploratory fishing survey in the Mississippi River, La Crosse, Wisconsin to Burlington, Iowa. Iowa Cons. Comm., Quart. Biol. Repts. 10(3):3-5.

Gengerke, T. 1977. Exploitation, harvest potential and basic life history of the paddlefish in the Upper Mississippi River. 39th Midwest Fish and Wildl. Conf. December 1977. Madison, WI.

Helms, D. 1974. Shovelnose sturgeon, *Scaphirynchus platorynchus* (Rafinesque), in the navigational impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

Hubley, R. 1961. Harvest and movement of channel catfish in the Upper Mississippi River. Wisc. Cons. Dept., West Cetral Area. Invest. Memo. No. 12, unpublished. 11 pp.

__________. 1963. Movement of tagged channel cafish in the Upper Mississippi River. Trans. Am. Fish. Soc. 92:165-170.

Iowa Conservation Commission. Fisheries Section. 1978. Commercial fisheries investigations; project completion report. Des Moines. 85 pp.

Larson, T. and R. Ranthum. 1977. The effects of commercial fishing through the ice on a winter congregation of channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*) in Pool 7 of the Mississippi River. Fish Manage Rept. No. 99. Wis. Dept. Nat. Res., Bur. Fish. Manage. Madison, WI.

Ranthum, R. 1971. A study of the movement and harvest of catfish tagged in the Lower Trempealeau Bay. Wisc. Dept. Nat. Res. Bur. Fish Manage. Rept. No. 50.

__________. 1974. Effects of commercial fishing on winter congregations of catfish in Pool 7 of the Mississippi River. Wis. Dept. Nat. Res., Madison, WI. National Marine Fisheries Service, Washington D.C. 9 pp.

Satek, B. 1948. Summary of catfish tagging experiment. UMRCC Invest. Rept. No. 22. 2 pp.

2) GREAT II

Information: A total of 43 references were made regarding the distribution, movement, and abundance of commercial fish in the GREAT II Region (Table 20). Of these six were made concerning the entire GREAT II Region. Seven each were made for Pools 11, 13, and 18. These references largely report results of studies on shovelnose sturgeon, paddlefish and channel catfish.

Voids: No references regarding distribution, movement, and abundance of commercial fish were made for Pools 20-22, and only one reference was made for Pool 12. Few commercial species, other than shovelnose sturgeon, paddlefish and channel catfish, were studied to determine their distribution movement and abundance.

Evaluation: Barnickol and Starrett (1951) reported the results of an extensive survey of the abundance and distribution of commercial and sport fishes at 31 sampling locations in the Mississippi River between Dubuque, Iowa and Caruthersville, Missouri. Cleary (1958) also reported the results of a sport and commercial fish survey and showed that in the Illinois-Iowa section of the Mississippi River (Pools 12-19), the ratio of the weight of game to commercial species was 29:63.

The distribution, movements, and abundance of shovelnose sturgeon was studied quite intensively in Iowa waters of the Mississippi River. Helms (1974) completed a series of reports which included descriptions of results of tagging and movement studies, surveys of commercial harvest, and populations. Boland (1974) also presented a summary of results of tagging studies on sturgeon in Iowa waters of the Mississippi River.

Helms (1975) completed as series of reports which included information about the abundance and distribution of channel catfish in Iowa waters of the Mississippi River. He recognized that their abundance varied between years and among locations, and investigated factors which could cause these differences.

Gengerke (1977) and the Iowa Conservation Commission (1978) studied the paddlefish in Iowa waters of the Mississippi. They reported the results of an extensive tagging and movement study, discussed the commercial harvest at various locations, and estimated the population size.

Recommendations: See Recommendations for 1) GREAT I.

Literature Cited:

Barnickol, P. and W. Starrett. 1951. Commercial and sport fishes of the Mississippi River between Caruthersville, Missouri and Dubuque, Iowa. Iowa Nat. Hist. Surv. Bull, 25(5):267-350.

Boland, T. 1974. Sturgeon.... a prehistoric remnant. Iowa Conserv. 33(10): 8-9, 11.

Cleary, R. 1958. Summaries of the 1956 and 1957 exploratory fishing survey in the Mississippi River, La Crosse, Wisconsin to Burlington, Iowa. Iowa Cons. Comm. Quart. Biol. Repts. 10(3):3-5.

Gengerke, T. 1977. Exploitation, harvest potential and basic life history of paddlefish in the Upper Mississippi River. 39th Midwest Fish and Wildl. Conf., December 1977. Madison, WI.

Helms, D. 1974. Shovelnose sturgeon, *Scaphirynchus platorynchus* (Rafinesque), in the navigational impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

__________. 1975. Variations in the abundance of channel catfish year classes in the Upper Mississippi River and causitive factors. Technical Series No. 75-1. Iowa Cons. Comm.

Iowa State Conservation Commission. Fisheries Section. 1978. Commercial Fisheries investigations; project completion report. Des Moines. 86 pp.

3) GREAT III

Information: A total of nine references were made regarding the distribution, movement and abundance of commercial fish in the GREAT III Region and the Upper Mississippi River. Of these, eight were made concerning the entire Upper Mississippi River. Most references dealt with some aspect of the distribution, movement and abundance of channel catfish.

Voids: No references regarding distribution, movement, and abundance of commercial fish were made specific to Pools 24-26 or the Lower Stretch.

Evaluation: Rasmussen (1979) provided an extensive and detailed summary of the distribution and relative abundance of Upper Mississippi River fishes, including the commercial fishes. Farabee's (1979) life history information of important sport and commercial fishes of the Upper Mississippi River included material regarding the distribution, movements and relative abundance, and Carlander (1969) also included similar information. Barnickol and Starrett (1951) reported the results of an extensive survey of the abundance and distribution of commercial and sport fishes at a number of sampling locations in the Missouri and Iowa waters of the Mississippi River and correlated this information with characteristics of the sampling locations.

Aside from these references there are several specific references which describe the distribution, movement, and abundance of commercial species in the Upper Mississippi River. Bailey and Cross (1954) described the distribution of sturgeons. Greenbank (1947) and Christenson (1952) reported extensive catfish studies, and Christenson (1952) discussed the extensive movements of channel catfish.

Recommendations: Since catfish is the most valuable commercial fish species in the Upper Mississippi River (Kline and Golden 1979;

Farabee 1979) it is apparent why it is so widely studied. In addition, they are also important in the sport fishery. They are not, however, the most abundant or most important commercial fish species. Aside from channel catfish, shovelnose stugeon and paddlefish have been widely studied. It is apparent that the distribution, movement, and abundance of many important commercial fish species in the Upper Mississippi River have not been well documented. It is recommented that special emphasis should be placed on those species which previously have been poorly studied, as well as those pools which previously have been received less attention.

Literature Cited

Bailey, R. and F. Cross. 1954. River sturgeon of the American genus, *Scaphirhynchus*: characteristics, distribution, and synonomy. Pap. Mich. Acad. SCi. ARts. Lett. 39(II): 169-208 (Zoology).

Barnickol, P. and G. Starrett. 1951. Commercial and sport fishes of the Mississippi River between Caruthersville, Missouri and Dubuque, Iowa. Nat. Hist. Surv. Bull. 25(5): 267-350.

Carlander, K. 1969. Freshwater fishery biology. Vol. I. Iowa State Univ. Press. 752 pp.

Farabee, G. 1979. Life histories of important sport and commercial fishes of the Upper Mississippi River. In: A compendium of fishery information on the Upper Mississippi River. Conti. UMRCC. 259 pp.

Greenbank, J. 1947. Catfish tagging. UMRCC Invest. Rept. No. 17. 1 p.

Kline, D. and J. Golden. 1979. Analysis of the Upper Mississippi River commercial fishery. In: A compendium of fishery information on the Upper Mississippi River. Contr. UMRCC. 259 pp.

Rasmussen, J. 1979. Distribution and relative abundance of the Upper Mississippi River fishes. In: A compendium of fishery information on the Upper Mississippi River. Contr. UMRCC. 259 pp.

e. Management Techniques

1) GREAT I

Information: A total of 39 references were reviewed regarding management techniques for commercial fish in the GREAT I Region (Table 19). Of these, 15 were made concerning the entire GREAT I Region, and 8 were made for Pool 9. Most references dealt with some aspect of the effects of the commercial catches on the populations, especially of channel catfish.

Voids: No references regarding management techniques of commercial fish were made for Pools 1-3, 5 or 5A; and only one reference was made for Pool 4. Aside from channel catfish, most species received little specific attention.

Evaluation: Finke (1966) reviewed trends in the commercial fishery of the five most important commercial species or species groups in the Wisconsin portion of the Mississippi River from 1960-1964, and the Iowa Conservation Commission (1978) evaluated the population, exploitation and life history of the paddlefish and made management recommendations. Aside from these reports, and a number of references primarily concerned with the status of the channel catfish fishery, there are few references which provide an in-depth review of the status of the commercial fishery or particular commercial species in GREAT I.

Since most important commercial fish species are not widely sought after by sport fishermen, they attract relatively little concern. Channel catfish, however, are readily accepted by both sport and commercial fishermen. As a result, conflicts between these interests have occurred and the status of the commercial fishery for the channel catfish has received much attention.

Fernholz (1977) analyzed the trends of the commercial catches of catfish in Pools 7-12 and concluded that Pool 9 was being overfished. Schoumacher (1963, 1964) investigated the cause of the decline in the commercial catch of catfish in the Iowa waters of the Mississippi River, and Helms (1969, 1970) discussed how a size-limit change on channel catfish might affect the sport and commercial catches.

Recommendations: It is recommended that trends in the commercial fishery continue to be monitored to evaluate whether significant changes occur. The trends in catches and the exploitation rates of individual species must also be determined. This information, together with an understanding of basic life history information and ecological requirements can be used to effectively manage the various species for continuing commercial and sport harvests.

Literature Cited:

Fernholz, W. 1977. Analysis of trends in the commercial catfish fishery of the Mississippi River, Pools 7-12. Wis. Dept. Nat. Res., Fish. Div. 1976-1977. Summ. Rept. No. 1. 4 pp.

Finke, A. 1966. A five-year summary of commercial fishing for carp, buffalo, sheepshead, catfish and bullhead on the Wisconsin portion of the Mississippi River - 1960-1964. Fish Manage. Rept. No. 8. Wisc. Cons. Dept., Fish Manage. Madison, WI.

Helms, D. 1969. Fifteen-inch size limit proposal for channel catfish in the Mississippi River. Iowa Cons. Comm. Quart. Biol. Rept. 22(4):94-54.

___________. 1970. Commercial fisherman's reactions to a proposed fifteen inch commercial catfish size limit. Iowa Cons. Comm. Quart. Biol. Repts. 22(3)13-25.

Iowa Conservation Commission. Fisheries Section. 1978. Commercial fisheries investigations; project completion report. Des Moines. 86 pp.

Schoumacher, R. 1963. A preliminary investigation into the cause of the decline in the commercial catch of catfish in the Iowa waters of the Mississippi River. Iowa Cons. Comm. Quart. Biol. Repts. 15(1):20-25.

__________. 1964. A brief preliminary report on commercial channel catfish. Iowa Cons. Comm. Quart. Biol. Rept. 16(1): 10-15.

2) GREAT II

Information: A total of 53 references were reviewed regarding management techniques for commercial fish in the GREAT II Region (Table 20). Of these, 15 were made concerning the entire GREAT II Region. Pool 11 was referenced most often.

Voids: No references regarding management techniques of commercial fish were made for Pools 20-22, and two references each were made for Pools 16 and 19.

Evaluation: Since the boundary between GREAT I and GREAT II has substantial overlap with state borders, there is much overlap and repetition of the references concerning management techniques and problems for commercial fisheries, particularly those references made by state agencies. As a result, many references for GREAT II deal with the management problem of the sport and commercial status of channel catfish (Helms 1975, Schoumacher 1963). Fisher (1951), however, discussed commercial fishing on the Mississippi River and commented on the fish, techniques, and problems faced by the commercial fishermen. Cleary (1958) summarized results of a fish survey and reported that the ratio of the weights of game to commercial fish in the Iowa-Wisconsin section of the river was 45:48, but in the Illinois-Iowa section, the ratio was 29:63.

Some references were also found which provided information regarding some less important commercial fish. Helms (1973, 1974) investigated the commerical harvest, life history, exploitation, and reporting system for shovelnose sturgeon. Gengerke (1977) and the Iowa Conservation Commission (1978) studied the exploitation, harvest potential and life history of paddlefish.

AD-A096 480 HAZLETON ENVIRONMENTAL SCIENCES CORP NORTHBROOK IL F/G 6/6
GREAT RIVER ENVIRONMENTAL ACTION TEAM (GREAT II). LITERATURE RE--ETC(U)
DEC 80 DACW25-79-C-0066
UNCLASSIFIED ES-9057 NL

3 OF 6
AD A
096480

Recommendations: See Recommendations for 1) GREAT I.

Literature Cited:

Cleary, R. 1958. Summaries of the 1956 and 1957 exploratory fishing survey in the Mississippi River, La Crosse, Wisconsin to Burlington, Iowa. Iowa Cons. Quart. Biol. Rept. 10(3):3-5.

Fisher, H. 1951. Men, rivers, nets-and fish. Mo. Conserv. 12(6):1-3.

Gengerke, T. 1977. Exploitation, harvest potential, and basic life history of paddlefish in the Upper Mississippi River. 39th Midwest Fish and Wildl. Conf. December, 1977. Madison, WI.

Helms, D. 1973. Progress report on the second year study of shovelnose sturgeon in the Mississippi River. Annual progress rept. for project 2-156-R-2. Iowa Cons. Comm. 33 pp.

______________. 1974. Shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the navigation impoundments of the Upper Mississippi River. Iowa Cons. Comm. 76 pp.

______________. 1975. Variations in the abundance of channel catfish year classes in the Upper Mississippi River and causitive factors. Technical Series No. 75-1. Iowa Cons. Comm.

Iowa Conservation Commission. Fisheries Section. 1978. Commercial fisheries investigations; project completion report. Des Moines. 86 pp.

Schoumacher, R. 1963. A preliminary investigation into the cause of the decline in the commerical catch of catfish in the Iowa waters of the Mississippi River. Iowa Cons. Comm. Quart. Biol. Repts. 15(1):20-25.

3) GREAT III

<u>Information</u>: A total of 15 references were reviewed regarding management techniques for commercial fish in the GREAT III Region and the Upper Mississippi River (Table 21). Of these, 2 were made concerning the entire GREAT III Region, and one was made for the Lower Stretch. Twelve references were made which included the entire Upper Mississippi River. Most references provide summary or overview information regarding the commercial fishery of the Upper Mississippi River.

<u>Voids</u>: No references regarding management techniques for commercial fish were made specific to Pools 24-26. Most reports dealt with the commercial fishery as a whole rather than addressing problems which may be unique to a particular species.

<u>Evaluation</u>: Sullivan (1971) investigated the factors affecting the status and the historical development of the Upper Mississippi River commercial fishery. He not only discussed the dynamics of the fishery and the fish populations, but also the origin and changes in consumer preferences and the effects on the markets, as well as the social and economic characteristics of the fishermen. Kline and Golden (1979) provided the most comprehensive history of the commercial fishery and analysis of the catch statistics. They discussed the distribution of fishing effort, the catches, the important commercial species from 1953-1977. They point out that since 1943 the management of most commercial species has been accomplished under the UMRCC, and that liberalization of regulations has been the rule. This management program has considered the factors of stock, supply, harvest and equitable division of the harvest and has been guided by the principle of utilization of the fish stocks without overharvest. Kline and Golden (1979) imply that the management program has been largely

successful since only the catfish group are the only commercially fished stock which shows signs of overfishing.

The stock assessment is accomplished largely through the evaluation of commercial fish catch statistics, such as Kline (1977) reported for carp and freshwater drum. These data are collected by employing a standardized technique adopted by the five states of the Upper Mississippi River Conservation Commission (Kline 1977, Kline and Golden 1979). Previously, the approach had been much less systematic (Greenbank, 1949). In addition to the approach used by the UMRCC, each state may exploy it's own special assessment techniques (Robinson 1973).

Most references dealt with the commercial fishery and the commercial fishes as a whole. Butler (1965) and Butler and Smith (1949) however, studied only the freshwater drum in various pools and discussed management implications.

Recommendations: See Recommendations for 1) GREAT I.

Literature Cited:

Butler, R. 1965. Freshwater drum, Aplodinotus grunniens, in the navigational impoundments of the Upper Mississippi River. Trans. Am. Fish. Soc. 94(4):339-349.

___________., and L. Smith, Jr. 1949. The age and rate of growth of the sheepshead, Aplodinotus grunniens (Rafinesque), in the Upper Mississippi River navigated pools. Trans. Am. Fish. Soc. 79: 43-54.

Greenbank, J. 1949. Fishing on the Upper Mississippi River, 1948. UMRCC Invest. Rept. No. 34. 13 pp.

Kline, D. 1977. Trends in the commercial harvest of carp (Cyprinus carpio) and freshwater drum (Aplodinotus grunniens) from the Upper Mississippi River between 1953 and 1972. 39th Midwest Fish and Wildl. Conf. Madison, WI.

Kline, D. and J. Golden. 1979. Analysis of the Upper Mississippi River commercial fishery. P. 82-117. In: Rasmussen, J. ed. A compendium of fishery information on the Upper Mississippi River. UMRCC. 2nd Ed. 259 pp.

Robinson, J. 1973. Research and management of commerical fisheries in Missouri; population sampling of commercial fish in the Mississippi River. Mo. Dept. Cons., Jefferson City. National Marine Fisheries Service. Washington, D.C. 52 pp.

Sullivan, J. 1971. The development and current status of the Upper Mississippi River commercial fishering. Ph.D. Thesis. Univ. of Mich., Ann Arbor, MI. 196 pp.

f. Harvest and Gear Evaluation

1) GREAT I

Information: A total of 65 references were reviewed regarding the harvest of commercial fish and gear evaluation for commercial fishing in the GREAT I Region (Table 19). Of these, 20 were made concerning the entire GREAT II Region, and 11 were made for Pool 9. Most references dealt with the aspects of commercial fishing statistics, trends in the commercial catches, gear evaluation or the impacts of commercial fishing on sport species.

Voids: No references were made regarding the harvest of commercial fish and gear evaluation for commercial fishing for Pools 1 or 2, and only one reference each was made for Pools 3, 5, 5A. Few references dealt with particular fish species in the commercial catches.

Evaluation: Kline and Golden (1979) provided a thorough review and analysis of the Upper Mississippi River commercial fishery and they included specific information for each pool or group of pools. Most references regarding commercial fishing in GREAT I dealt with some aspects of fishery catch or catch value statistics or trends in the commercial catches. Ackerman (1974) reported the 1974 commercial catch for Iowa and the 10 year trends in the Iowa commercial catches in the Mississippi River. Merz (1975) summarized 14 years (1960-1973) of commercial catches of the five most important species (carp, buffalo, freshwater drum, catfish and bullheads) caught in Wisconsin waters of the Mississippi River. The value of these fish during that period was approximately five million dollars. Kelley (1953) evaluated factors influencing the catch using trap nets in Pool 8.

Since fishing gear is so important to commercial fishing success, a number of references were concerned with some aspects of gear

evaluation. Fernholz (1977) evaluated the use of sonar scanning devices as a tool to help commercial fishermen locate schools of fish. Merz and Holzer (1977) experimentally fished deep water trap nets in Lake Pepin during two winters and reported that the technique was not profitable.

Aside from the aspects of commercial fishing results and gear evaluation, a number of references discussed the effects of commercial fishing on sport fishes. Fritz and Starrett (1957) discussed the impact of commercial fishing for crappies and concluded that two years of commercial fishing and liberalized sport fishing regulations had no effect on the fishery. Ranthum (1974), after a two-year study found that commercial gillnetting operations in Pool 7 resulted in definite losses of non-commercial fish and waterfowl.

Recommendations: It is recommended that commercial catch statistics should continue to be collected, evaluated, and analyzed for application in a management program. Gear and techniques should continue to be evaluated to provide advances in the fishery, but the status of individual species, associated species, and the community structure must also be evaluated and monitored to avoid undesirable impacts.

Literature Cited:

Ackerman, G. 1974. 1974 commercial fishing statistics. Pool 9-19, Mississippi River. Iowa Cons. Comm. pp. 167-176.

Fernholz, W. 1977. Evaluation of sonar sounding equipment. Wisc. Dept. Nat. Res. Fish. Div. 1975-76. Sum. Rept. No. 10. 8 pp.

Fritz, A. and W. Starrett. 1957. The crappie story in Illinois. Outdoors in Illinois. Illinois Dept. Cons. 4(2):11-14.

Kelley, D. 1953. Fluctuation in trap-net catches in the Upper Mississippi River. U.S. Fish and Wildl. Serv. Spec. Sci. Rept. Fish. 101. 38 pp.

Kline, D. and J. Golden. 1979. Analysis of the Upper Mississippi River commercial fishery. P. 82-117. In: Rasmussen, J. ed. A compendium of fishery information on the Upper Mississippi River. UMRCC. 2nd ed. 259 pp.

Merz, E. 1975. A fourteen-year summary of commercial fishing for carp, buffalo, freshwater drum, catfish and bullhed on the Wisconsin portion of the Mississippi River, 1960-1973. Fish Manage. Rept. No. 84. Wis. Dept. Nat. Res., Bur. Fish and Wild. Manage.

Merz, E., and J. Holzer. 1977. Evaluation of deep water trap nets and commercial gear in Pool 4A (Lake Pepin), Mississippi River. Fish Manage. Rept. 97. Bur. Fish. Manage., Wis. Dept. Nat. Res. Madison, WI.

Ranthum, R. 1974. The effects of a commercial gill net fishery on the fish and waterfowl of Pool 7, Mississippi River. Wis. Dept. Nat. Res., Madison, WI. Bur. Fish Wildl. Manage. National Marine Fisheries Service. Washington, D.C. 93 pp.

2) GREAT II

Information: A total of 98 references were reviewed regarding the harvest of commercial fish and gear evaluation for commercial fishing in the GREAT II Region (Table 20). Of these, 21 were made concerning the entire GREAT II Region, and eleven references were made for Pool 11. Most references presented information on commercial fishing statistics and were concerned with the numbers, weight, and value of the various species caught.

Voids: Only one each was made regarding the harvest of commercial fish and gear evaluation for commercial fishing for Pools 20-22. Few references dealt with separate fish species which make up the commercial catch.

Evaluation: Kline and Golden (1979) provided a thorough review and analysis of the Upper Mississippi River commercial fishery, and they included specific information for each pool or group of pools. Robinson (1973a) also provided a discussion and summary of research and management of commercial fisheries in the Missouri portion of GREAT II.

Most references, however, were largely concerned with the presentation of commercial fish catch statistics (Robinson 1936b, Helms 1966, Fernholz 1971). Helms (1967) discussed long-term trends in the channel catfish fishery; and Kelley (1949) discussed the possible impact of a particular gear type.

Recommendations: See Recommendations for 1) GREAT I.

Literature Cited:

Fernholz, W. 1971. Mississippi River commercial fishing statistics, 1971. Wisc. Dept. Nat. Res., Bur. Fish. Manage. 24 pp.

Helms, D. 1966. Commercial fishing statistics for the Mississippi River bordering Iowa. Iowa Cons. Comm. Quart. Biol. Rept. 18(3):23-25.

___________. 1967. Trends in channel catfish harvest in the Mississippi River. Iowa Cons. Comm. Quart. Biol. Rept. 19(4):27-31

Kelley, D. 1949. Preliminary report on the buffalo net. UMRCC Invest. Rept. No. 31. 11 pp.

Kline, D. and J. Golden. 1979. Analysis of the Upper Mississippi River commercial fishery. P. 82-117. In: Rasmussen, J. ed. A compendium of fishery information on the Upper Mississippi River. UMRCC. 2nd ed. 259 pp.

Robinson, J. 1973a. Research and management of commercial fisheries in Missouri; population sampling of commercial fish in the Mississippi River. Mo. Dept. Cons. Jefferson City. National Marine Fisheries Service.

____________. 1973b. Collection and compilation of commercial fisheries harvest data in Missouri: 1965-1971. NMFS Proj. No. 4-3-R-8. Work Plan 21. Job No. 2. Mo. Dept. Cons. 37 pp.

3) GREAT III

Information: A total of 55 references were reviewed regarding the harvest of commercial fish and gear evaluation for commercial fishing in the GREAT III Region and the total Upper Mississippi River. Of these, 4 were made concerning the entire GREAT III Region, and two were made for the Lower Stretch. Forty-six references were made which included the entire Upper Mississippi River. Most references reported the commercial fishing catch statistics and value.

Voids: Only one reference each was made regarding the harvest of commercial fish and gear evaluation for commercial fishing specific to Pools 24-26. Few references discussed the harvest of particular species.

Evaluation: Kline and Golden (1979) provided a comprehensive review and analysis of the Mississippi River commercial fishery. They discussed four basic aspects of the commercial fishery: 1) size of annual harvest; 2) value of annual harvest; 3) predictions of future harvests; and 4) need for regulation of harvest. They demonstrated how the size and value of the catch has varied since 1953, how different types of gear have been used, and the importance of various pools or groups of pools. The commercial fish harvest annually averages over 11 million pounds and has a value of over $1 million and carp, buffalo, catfish, and freshwater drum are the most important commercial fishes. The assessment of the stocks of these fish has been important for the management of the fishery; however, Kline and Golden (1979) reported that there have been no recent thorough assessments of the entire fishery. Nonetheless, the stocks of most of the important commercial fishes apparently are adequate, except for the catfish group. This group shows signs of overharvest.

Kline and Golden (1979) provided a substantial overview of the recent Upper Mississippi River commercial fishery; however, they provided no detailed analysis of particular species. Apparently, Butler (1962) and Kline (1977) are the only authors who provided such analyses. Most other references dealt with the reporting of catch statistics (Robinson 1973, Fiedler 1941). However, as in other GREAT regions, discussions of commercial gear evaluation and fishing techniques were important (Greenbank 1945, 1946; De Cook and Cleary 1960; Starrett and Barnickol 1955).

Recommendations: See Recommendations for 1) GREAT I.

Literature Cited:

Butler, R. 1962. The status of the freshwater drum, *Aplodinotus grunniens*, Rafinesque, in the commercial fishery of the Upper Mississippi River. Ph.D. Thesis. Univ. of Minn. 183 pp.

De Cook, R. and R. Cleary. 1960. Fishing gear evaluation, Mississippi River - 1960. Iowa Cons. Comm. Mimeo. unpublished. 5 pp.

Fiedler, R. 1941. Fishery industries of U.S., 1939. Admin. Rept. No. 41. Comm. Fish. for fiscal year 1940. App. 3:185-554.

Greenbank, J. 1945. Notes on slat traps. UMRCC Invest. Rept. No. 2. 1 p.

__________. 1946. A comparison of the characteristics of various types of commercial fishing gear. UMRCC Invest. Rept. No. 38. 18 pp.

Kline, D. 1977. Trends in the commercial harvest of carp (*Cyprinus carpio*) and freshwater drum (*Aplodinotus grunniens*) from the Upper Mississippi River between 1953 and 1972. 39th Midwest Fish and Wildl. Conf, Madison, WI.

Kline, D. and J. Golden. 1979. Analysis of the Upper Mississippi River commercial fishery. P. 82-117. In Rasmussen, J. ed. A compendium of fishery information on the Upper Mississippi River. UMRCC. 2nd ed. 259 pp.

Robinson, J. 1973. Collection and compilation of commercial fisheries harvest data in Missouri: 1965-1971. NMFS Proj. No. 4-3-R-8. Work Plan 21. Job No. 2. Mo. Dept. Cons. 37 pp.

Starrett, W., and P. Barnickol. 1955. Efficiency and selectivity of commercial fishing devices used on the Mississippi River. Ill. Nat. Hist. Surv. Bull. 26(4):325-366.

g. Parasites and Diseases

1) GREAT I

Information: A total of three references were reviewed regarding parasites and diseases of commercial fish in the three GREAT Regions and the Upper Mississippi River (Tables 19-21). Of these, two were made concerning Pool 6 and one was for Pool 1.

Voids: No references regarding parasites and diseases of commercial fish were made for any Pools except Pools 1 and 6. No references were made which included any entire GREAT region or the entire Upper Mississippi River.

Evaluation: Evans (1969) evaluated the incidence of glochidia infestation of several commercial fishes in Pool 6. He reported that the rate of infestation was dependent on the fish's body size and feeding habits, and that golden redhorse probably is not a host species. Allen (1970) discussed acanthocephalan infestation in six fish species, but found infestations only in spotted suckers, channel catfish, and freshwater drum; but the parasite apparently does not affect the host's coefficient of condition. Turner (1977) found that of 88 catostomids representing three species which he examined, more than 90% were infested with endoparasites or ectoparasites.

Recommendations: Usually parasites and diseases are not a significant factor in fish populations, and ordinarily would not affect the commercial harvest. It is recommended, however, that some surveys and systematic monitoring of the incidence of diseases, parasites and anomolies should be carried out to determine the incidence of these conditions in the fish populations, since a significant or abrupt change in the incidence of diseases, parasites or anomolies could result from some environmental perturbation.

Literature Cited:

Allen, C. 1970. Acanthocephalan infestation of various bottom feeding fish in Pool No. 6 of Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN.

Evans, B. 1969. A study of glochidia infestation in redhorse, walleye and bluegill in Pool No. 6, Mississippi River. M.S. Thesis. St. Mary's College, Winona, MN.

Turner, W. 1977. The ectoparasites and digestive tract parasites infecting three species of Catostomidae in the Mississippi River near Becker, Minnesota. M.S. Thesis. St. Cloud Univ., St. Cloud, MN.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

3. Forage Fish

a. GREAT I

For the discussion of forage fish, all three GREAT Regions have been combined.

1) Spawning and Reproduction

Information: Only one reference was reviewed concerning spawning and reproduction of forage fish of the Upper Mississippi River (Tables 22-24). This reference dealt with the aspects of forage fish spawning and reproduction along with other life history information throughout the Upper Mississippi River.

Voids: There are no references which deal with the aspects of forage fish spawning and reproduction specific to any of the various pools in any of the GREAT Regions.

Evaluation: Carlander (1969) provided a thorough literature review and discussion of fish life history information, including the aspects of spawning and reproduction, for North American fish species. Consequently, he included most forage fish typically found in the Upper Mississippi River

Recommendations: Forage fish commonly do not attract close attention in biological studies. They are, however, particularly important in the community structure and as a food source for other fish species which typically attract more attention. It would be valuable, then, to have a greater understanding of the various life history aspects of forage fish.

It is recommended, therefore, that studies be performed which will add to the general knowledge and understanding of forage fish.

In addition, whenever possible, those studies which are primarily concerned with ecological parameters of other fish categories or fisheries surveys, should also be designed to obtain information concerning forage fish. At least, those species identified as being most important in the food chain of key sport or commercial fish species should be included in studies.

Literature Cited:

Carlander, K. 1969. Handbook of freshwater fish biology. Vol. 1. The Iowa State Univ. Press. Ames, IA. 752 pp.

2) Age and Growth

Information: A total of 5 references were reviewed concerning age and growth of forage fish in the GREAT I, II, and III Regions (Tables 22-24). Three references were made for the GREAT I Region; one each for Pools 1 and 8, and one which included the entire GREAT I Region. Two references were made concerning the entire Upper Mississippi River.

Voids: There are no references which deal with the aspects of forage fish age and growth in Pools 2 through 7 or Pools 9 and 10 in GREAT I or in any pools of the GREAT II or III Regions.

Evaluation: Carlander (1969) provided a thorough literature review and discussion of fish life history information, including the aspects of age and growth, for North American fish species. In that report, he included most forage fish typically found in the Upper Mississippi River. Copp (1967) and Willfahrt (1962) included comments on the age and growth of gizzard shad in the Upper Mississippi River. Morgenweck (1971) described the age and growth of twelve minnow species in Pool 1, and Thiel (1977) described the age and growth of four minnow species in Pool 8.

Recommendations: See Recommendations for 1) Spawning and Reproduction.

Literature Cited:

Carlander, K. 1969. Handbook of freshwater fish biology. Vol. 1. The Iowa State Univ. Press. Ames, IA. 752 pp.

Copp, J. 1967. Growth study of the young gizzard shad (Dorosoma cepedianum) in the Upper Mississippi River. B.A. Thesis. St. Mary's College. Winona, MN. 22 pp.

Morgenweck, R. 1971. A survey and distribution study of the Cyprinid minnows (Family Cyprinidae) in the Monticello region of the Mississippi River. M.A. Thesis. St. Cloud St. Univ., St. Cloud, MN. 63 pp.

Thiel, P. 1977. Age, growth, and food habits of 4 selected minnows from navigation Pool 8 of the Upper Mississippi River. M.S. Thesis. Univ. Wis., La Crosse, WI.

Willfahrt, G. 1962. A growth analysis of the gizzard shad in the Upper Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 26 pp.

3) Feeding Habits

Information: A total of 5 references were reviewed concerning the feeding habits of forage fish in the Upper Mississippi River (Tables 22-24). One reference dealt with forage fish feeding habits along with other life history information throughout the Upper Mississippi River. Three references were made for the GREAT I Region; one each for Pools 1, 8, and 19, and one for the entire GREAT I Region.

Voids: There are no references which deal with the aspects of forage fish feeding habits in Pools 2-7 or Pools 9 and 10 in GREAT I or in any of the pools in GREAT II or III, except Pool 19.

Evaluation: Carlander (1969) provided a thorough literature review and discussion of fish life history information including the feeding habits for North American fish species. Consequently, he included most forage fish typically found in the Upper Mississipi River. Jude (1973) and Maurer (1962) discussed the feeding habits of gizzard shad in the Upper Mississippi River; Morgenweck (1971) included comments on the feeding habits of four minnow species in Pool 8.

Recommendations: See Recommendations for 1) Spawning and Reproduction.

Literature Cited:

Carlander, K. 1969. Handbook of freshwater fish biology. Vol. 1. The Iowa State Univ. Press. Ames, IA. 752 pp.

Jude, D. 1973. Food and feeding habits of gizzard shad in Pool 19 Mississippi River. Trans. Amer. Fish. Soc. 102 (2): 378 - 383.

Maurer, J. 1962. Stomach analysis of the gizzard shad Dorosoma cepedianum in the Upper Mississippi River. B. S. Thesis. St. Mary's College, Winona, MN. 21 pp.

Morgenweck, R. 1971. A survey and distribution study of the Cyprinid minnows (Family Cyprinidae) in the Monticello region of the Mississippi River. M.A. Thesis. St. Cloud St. Univ., St. Cloud, MN. 63 pp.

4) Distribution, Movement and Abundance

Information: A total of 12 references were reviewed concerning the distribution, movement and abundance of forage fish in the GREAT I, II and III Regions (Tables 22-24). Of these, seven references dealt with the distribution of particular forage species in the Upper Mississippi River, and one reference dealt with general aspects of forage fish distribution, movement, and abundance in the Upper Mississippi River. Three references were concerned with the distribution and relative abundance of forage fishes in Pool 1, and one reference described the distribution of minnows and darters in the GREAT I Region.

Voids: There are no references which deal with the aspects of forage fish distribution, movement, or abundance in any of the various pools in any of the GREAT regions except Pool 1.

Evaluation: Carlander (1969) provided a thorough literature review and discussion of fish life history information, including the aspects of distribution, movements, and abundance, for North American fish species. Consequently, he included most forage fish typically found in the Upper Mississippi river. Braasch and Smith (1965), Burr (1974), Burr and Smith (1976), Copp (1967), Hubbs (1951), Trautman (1931), and Tsai and Raney (1974) were concerned largely with the distribution of particular minnows, percids or cyprinodontids in the Upper Mississippi River. Morgenweck (1971), Morgenweck and Hopwood (1971) and Ott (1973) and Underhill (1957) surveyed the distribution and relative abundance of forage fish, particularly minnows, in Pool 1, and the GREAT I Region respectively.

Recommendations: See Recommendations for 1) Spawning and Reproduction.

Literature Cited:

Braasch, M. and P. Smith. 1965. Relationships of the topminnows *Fundulus notatus* and *Fundulus olivaceus* in the Upper Mississippi River valley. Copeia. 1965 (1): 46-53.

Burr, B. 1974. Taxonomic status of stonerollers (*Campostoma aggasiz*) in the Upper Mississippi River Valley (Pices: Cyprinidae). M.S. Thesis. Univ. Ill.

Burr, B., and P. Smith. 1976. Status of the large-scale stoneroller *Campostoma oligolepis*. Copeia (3): 521-531.

Carlander, K. 1969. Handbook of freshwater fish biology. Vol. 1. The Iowa State Univ. Press. Ames, IA. 752 pp.

Copp, J. 1967. Growth study of the young gizzard shad (*Dorosoma cepedianum*) in the Upper Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 22 pp.

Hubbs, C. 1951. *Notropis amnis*, a new cyprinid fish of the Mississippi fauna, with two subspecies. Occ. Pap. Mus. Zool. Mich. 530: 1-30.

Morgenweck, R. 1971. A summary and distribution study of the Cyprinid minnows (Family Cyprinidae) in the Monticello region of the Mississippi River. M.A. Thesis. St. Cloud St. Univ., St. Cloud, MN. 63 pp.

Morgenweck, R., and A. Hopwood. 1971. Cyprinid minnows of the Mississippi River at Monticello, Minnesota. St. Cloud St. College, St. Cloud, MN.

Ott, J. 1973. Flourescent dyemarking of Cyprinid minnows (Family Cyprinidae) and other small fish for population studies in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud State Univ., St. Cloud, MN. 77 pp.

Thiel, P. 1977. Age, growth, and food habits of 4 selected minnows from navigation Pool 8 of the Upper Mississippi River. M.S. Thesis. Univ. Wis., La Crosse, WI.

Trautman, M. 1931. *Notropis volucellus wickliffi*, a new subspecies of cyprinid fish from the Ohio and Upper Mississippi rivers. Ohio J. Sci. 31(6):468-474.

Tsai, C. and E. Raney. 1974. Systematic of the *Etheostoma zonale* Pisces Percidae. Copeia (1):1-24.

Underhill, J. 1957. The distribution of Minnesota minnows and darters. Occas. Pap. Minn. Mus. Nat. No. 7. 45 pp.

5) Management Techniques

Information: None

Voids: There are no references which deal with forage fish management techniques in any of the various pools in any of the GREAT Regions (Tables 22-24).

Evaluation: None

Recommendations: The importance of forage fish to the community structure and to the food chain is widely recognized. Their populations, however, are generally considered to be sufficiently stable; and fluctuations in forage fish populations are rarely considered to greatly affect the populations of prey species, particularly in a complex ecosystem such as the Upper Mississippi River. Consequently, they are rarely the primary organism considered in a management scheme. As a result, few management techniques are designed specifically for forage fish. In spite of this, it is recommended that in any study of management techniques or in any management program, the effects on forage fish populations also be considered and evaluated. It may be determined that an appropriate management scheme for some species may depend on the management of a forage fish.

6) Parasites and Diseases

Information: None

Voids: There are no references which deal with the aspects of forage fish parasites and diseases in any of the various pools in any of the GREAT Regions (Tables 22-24).

Evaluation: None

Recommendations: See Recommendations for 1) Spawning and Reproduction.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

4. General Fisheries

The subject of general fisheries includes those references in which fishes from all three fish categories (sport, commerical and forage) may be represented.

a. Spawning and Reproduction

1) GREAT I

For the discussion of spawning and reproduction of general fish, all three GREAT Regions have been combined.

Information: Only six references were found regarding the spawning and reproduction of general fish (Tables 25-27). All six references were to fishes of Pool 14.

Voids: No information was obtained regarding the spawning and reproduction of general fish in any of the pools, except Pool 14.

Evaluation: Industrial BIO-TEST Laboratories, Inc. (1972) described the spawning times and areas for 12 species of fish, primarily game species, in Pool 14 prior to construction of an electric power generating station, while Industrial BIO-TEST Laboratories, Inc. (1973) and NALCO Environmental Sciences (1977) in a series of annual reports documented the spawning seasons of the fish community in Pool 14 based on catches of larval fish.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Industrial BIO-TEST, Inc. 1972. Locke, M., ed. Determination of the thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972) 2 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1973. Locke, M. and H. Eiler. eds. Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

NALCO Environmental Sciences. 1977. Gerhold, R. ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

b. Age and Growth

1) GREAT I

For the discussion of age and growth of general fish, all three GREAT Regions have been combined.

Information: Only five references were found regarding the age and growth of general fish (Tables 25-27). One reference was from Pool 1 and four were not specific to any pool or GREAT Region.

Voids: No information was obtained regarding the age and growth of general fish specific to any pool besides Pool 1.

Evaluation: Neudahl (1976) presented basic age and growth information for six fish species in Pool 1. Carlander (1950, 1953) provided general information on age and growth of many species, many of which may be found in the Upper Mississippi River; while Christenson (1957) and Christenson and Smith (1965) provided more specific informaton on the age and growth of species common to backwater areas of the Upper Mississippi River.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Carlander, K. 1950. A handbook of freshwater fishery biology. Wm. C. Brown Co. Dubuque, IA. 281 pp.

Carlander, K. 1953. First supplement to a handbook of freshwater fishery biology. Wm. C. Brown Co. Dubuque, IA.

Christenson, L. 1957. Some characteristics of the fish population in backwater areas of the Upper Mississippi River. M.S. Thesis. Univ. Minn., St. Paul, MN. 125 pp.

Christenson, L. and L. Smith. 1965. Characteristics of fish populations in Upper Mississippi River backwater areas. U.S. Dept. Int., Fish and Wildlife Service. Circular 212. 53 pp.

Neudahl, L. 1976. Age and growth of the major fish species in the Mississippi River near Becker, Minnesota. M.S. Thesis. St. Cloud State Univ., St. Cloud, MN. 113 pp.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

c. Feeding Habits

1) GREAT I

For the discussion of feeding habits of general fish, all three GREAT Regions have been combined.

Information: A total of 12 references were reviewed regarding the feeding habits of general fish (Tables 25-27). Seven were found for Pool 19, and each was found for GREAT Regions I and II, and three were not specific to any GREAT Region.

Voids: No references were found specific to any pool of the Upper Mississippi River, except Pool 19.

Evaluation: Greene (1935) included comments about the feeding habits of fishes found largely in GREAT Regions I and II, while Carlander (1950) and Forbes (1888 a,b) included comments about feeding habits of fishes found in the Upper Mississippi River. Other references report the feeding habits and relationships of various species in Pool 19, and most, demonstrated the importance of bottom organisms to the fish populations. These studies are largely summarized by Jude (1968) and Gale et al. (1969).

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Carlander, K. 1950. A handbook of freshwater fishery biology. Wm. C. Brown Co. Dubuque, IA. 281 pp.

Forbes, S. 1888a. The food of the fishes of the Mississippi River Valley. Trans. Am. Fish. Soc. 17:1-17.

Forbes, S. 1888b. Notes on the food of the fishes of the Mississippi River Valley. Trans. Am. Fish. Soc. 17:37-66.

Gale, W. D. Jude and R. Ranthum. 1969. Distribution of bottom fauna and its utilization by fish in the Fort Madison Section of Pool 19, Mississippi River. Iowa Co-op. Fish. Unit Proj. No. 1373. Ames, IA.

Greene, C. 1935. The distribution of Wisconsin fishes. Wis. Cons. Comm. Madison, WI. 235 pp.

Jude, D. 1968. Bottom fauna utilization and distribution of 10 species of fish in Pool 19, Mississippi River. Masters Thesis. Iowa State University of Science and Technology. Ames, IA. 238 pp.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

d. Distribution, Movement, and Abundance

1) GREAT I

Information: A total of 57 references were reviewed regarding the distribution, movement, and abundance of general fish in the GREAT I Region (Table 25). References were found for each pool in the region and 14 references were made which referred to the entire GREAT I Region. Pool 1 was referred to most often.

Voids: Though references were made regarding the distribution, movement, and abundance of combined fishes for all pools in GREAT I, certain pools were not studied as intensively as others. Pools 5A and 10 included only two references each.

Evaluation: Rasmussen (1979) provided a comprehensive review of the distribution and relative abundance of Upper Mississippi River fishes; the reviews by Eddy and Underhill (1974) and Greene (1935) were more general. In addition to these, a variety of surveys, such as those by Molamphy and Cleary (1959, 1960), describe the relative abundance of fish caught at various locations.

A number of references were found which reported studies designed to simply assess the fish populations in a restricted area, usually to evaluate the impact of some environmental change. Skrypek (1969) and Northern States Power Company (1973) are typical of these types of studies. Other references reported results of general surveys by individual investigators (Barels 1976) or agencies (Finke 1964). Finally some references reported the results of studies designed to evaluate fish populations associated with specific conditions (Fernholz 1977) or habitats (Greenbank 1947).

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Barels, B. 1976. Fish populations of the Mississippi River near Becker, Minnesota. M.S. Thesis. St. Cloud State Univ., St. Cloud, MN. 59 pp.

Eddy, S., and J. Underhill. 1974. Northern fishes (with special reference to the Upper Mississippi River Valley). 3rd Ed. University of Minnesota Press. Minneapolis, MN. 414 pp.

Fernholz, W. 1977. Winter sonar scanning - Pool 7, Mississippi River. Wis. Dept. Nat. Res., Fish. Div. 1976-77. Sum. Rept. No. 2. 2 pp.

Finke, A. 1964. Mississippi River electrofishing survey in Pools 3 and 4 during 1963. Wisc. Cons. Dept., West Central Area. Invest. Memo. No. 20. unpublished. 28 pp.

Greenbank, J. 1947. Fish population study, Miller Lake. UMRCC Invest. Rept. No. 18. 3 pp.

Greene, C. 1935. The distribution of Wisconsin fishes. Wis. Cons. Comm. Madison, WI. 235 pp.

Molamphy, T., and R. Cleary. 1959. Electro-fishing survey of Iowa waters of Mississippi River - May 1959. Iowa Cons. Comm. Admin. Summary. Mimeo. unpublished. 24 pp.

__________. 1960. Electro-fishing surveys of Iowa waters of Mississippi River-1960. Iowa Cons. Comm., Admin. Summary. Mimeo. unpublished. 2 pp.

Northern States Power Company. 1973. Prairie Island Nuclear Generating Plant. Units 1 and 2. Environmental Monitoring and Ecological Studies Program. Annual Report. 1972. Minneapolis, MN. 754 pp.

Rasmussen, J. ed. 1979. A compendium of fishery information on the Upper Mississippi River. A contribution of the UMRCC. Second edition. 259 pp.

Skrypek, J. 1969. Difference in the composition of the fish population in Pool 2 and other areas of the Mississippi River as related to the waste from the Twin City Metropolitan Area - 1964. Minn. Dept. Nat. Res., Invest. Report. No. 307.

2) GREAT II

Information: A total of 89 references were compiled and reviewed regarding the distribution, movement, and abundance of general fish in GREAT II (Table 26). References were found for each pool in the region and 15 references were made which referred to the entire GREAT II Region.

Voids: Only one reference was made for Pool 22.

Evaluation: Rasmussen (1979) provided a comprehensive review of the distribution and relative abundance of Upper Mississippi River fishes; and other references, such as Smith (1965) provided a more general overview. Dunham (1979, 1971), however, reported a detailed investigation of the tailwater habitat below most dams in GREAT II. He found that the tailwater below Lock and Dam 13 produced the most fish, while the tailwater below Lock and Dam 16 had the greatest variety of fish, and the tailwater below Lock and Dam 15 had the least number of fish and variety. Kelley (1946, 1947) reported the results of test netting operations in Iowa and Wisconsin waters. Those references provide a relatively early description of the species composition and relative abundance of a substantial catch of fish.

A number of recent references are concerned with environmental impact assessments of developments along the river (Commonwealth Edison Company, 1975; NALCO Environmental Sciences, 1977). Other references report results of studies to survey the population status, species composition and relative abundance in various reaches of the river. In a typical report, Bertrand and Russell (1974) describe the results of fish sampling in Pools 17 and 18. They reported the presence of 40 species, with shad, bluegill, carp, crappies, and largemouth bass being the most common species.

Some studies were designed to evaluate some particular aspects of fish ecology. Kline et al. (1975) made a fishery survey to determine fish and habitat diversity in tow units. Latvaitis (1974) discussed investigations using tagged fish to determine whether fish would pass through a thermal plume created by heated water discharge from a power generating plant. Ranthum (1969) discussed the distribution in various habitat types of several fish species in Pool 19, and Muench (1978) estimated the standing crop of fish species in a Pool 14 backwater.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commerical Fish, and 3. Forage Fish.

Literature Cited:

Bertrand, B. and K. Russell. 1974. Fish populations survey of stations in Pool 17 and 18 of the Mississippi River. Illinois Dept. Cons., Div. of Fisheries.

Commonwealth Edison Company. 1975. Three-Sixteen (a & b) demonstration, Quad-Cities Nuclear Station, Mississippi River. Chicago, IL.

Dunham, L. 1970. Fish sampling by electro-fishing below ten navigation dams on the Mississippi River. Illinois Dept. Cons., Div. of Fisheries. 10 pp.

_______________. 1971. Fish sampling by electro-fishing gear below navigation dams no. 12-26 on the Mississippi River. Illinois Dept. Cons., Div. of Fisheries.

Kelley, D. 1946. Test and operations, northern section, 1946. UMRCC Invest. Rept. No. 32.

_______________. 1947. Species composition of the catch of the test-net operations, northern unit, 1946. UMRCC Invest. Rept. No. 15. 2 pp.

Kline, D., J. Golden, and M. Wade. 1975. Mississippi River fishery classification survey. Huron Island (mile 421-426) and Wyoming Slough (mile 458-463). Iowa Cons. Comm. Proj. No. 75-III-C-116:135-145.

Latvaitis, P. 1974. Preliminary fish tagging investigation in Pool 14 of the Mississippi River. Drum and Croaker. Volume 15(74) No. 1.

Muench, B. 1978. A standing crop estimate for a Pool 14 backwater area. Pap. Pres. at 16th. Ann. Am. Fish. Soc. Mtg., Pekin, IL, Feb. 21-23.

NALCO Environmental Sciences. 1977. Operational environmental monitoring in the Mississippi River near Quad-Cities (February 1977 through July 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

Ranthum, R. 1969. Distribution and food habits of several species of fish in Pool 19, Mississippi River. M.S. Thesis. Iowa State Univ. Ames, IA. 207 pp.

Rasmussen, J. ed. 1979. A compendium of fishery information on the Upper Mississippi River. A contribution of the UMRCC. Second edition. 259 pp.

Smith, P. 1965. A preliminary annotated list of the lampreys and fishes of Illinois. Illinois Nat. Hist. Surv. Biol. Notes No. 54. 12 pp.

3) GREAT III

Information: A total of 26 references were reviewed regarding the distribution, movement and abundance of general fish in the GREAT III Region and 12 references were made concerning the entire Upper Mississippi River (Table 27). At least three references were made for each pool.

Voids: Though a number of references are available for all of the pools and reaches of the river, few references dealt with fish movements.

Evaluation: Rasmussen (1979) provided a comprehensive review of the distribution, movement and relative abundance of Upper Mississippi River fishes, and Pflieger (1975) and Smith (1965) also included comments about fishes from the GREAT III Region. Aside from these general references, there were several references which reported results of surveys designed to evaluate species composition and relative abundance of fish in various pools of GREAT III (Bertrand and Lockhart 1973, Bertrand and Miller 1973) and the Lower Stretch of GREAT III (Emge et al. 1974). Ragland (1974), however, compared particular fish habitat types in the Lower Stretch and reported that minnows were approximately six times more abundant in the side channels than the main channel, but largemouth bass were found only in the main channel.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Bertrand, B. and R. Lockhart. 1973. Fish population survey of the habitat types in Pool 26 and below 26 in the Alton area of the Mississippi River. Illinois Dept. Cons., Div. of Fisheries.

Bertrand, B., R. Lockhart and T. Miller. 1973. Fish population survey of habitat types in Pool 25 of the Mississippi River. Illinois Dept. Cons., Div. of Fisheries.

Carlander, K. 1950. A handbook of freshwater fishery biology. Wm. C. Brown Co. Dubuque, IA. 281 pp.

_______________ . 1953. First supplement to a handbook of freshwater fishery biology. Wm. C. Brown Co. Dubuque, IA.

Emge, W., R. Solomon, J. Johnson, C. Bingham, and B. Colbert. 1974. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River. Army Engineer Waterways Experiment Station. Vicksburg, MS. 621 pp.

Jordan, D. and B. Evermann. 1896. The fishes of North and Middle America. U.S. Nat. Hist. Mus. Bull. 47. 1240 pp.

Pflieger, W. 1975. The fishes of Missouri. Mo. Dept. Cons. 342 pp.

Ragland, D. 1974. Evaluation of three side channels and the main channel border of the Middle Mississippi River as fish habitat. Springfield, VA prep. for U.S. Army Eng. Waterways Experiment Station. AD-786 142.

Rasmussen, J. ed. 1979. A compendium of fishery information on the Upper Mississippi River. A contribution of the UMRCC. Second edition. 259 pp.

Smith, P. 1965. A preliminary annotated list of the lampreys and fishes of Illinois. Illinois Nat. Hist. Surv. Biol. Notes No. 54. 12 pp.

Smith, P., A. Lopinot and W. Pflieger. 1971. A distributional atlas of Upper Mississippi River fishes. Bio. Notes No. 73. 20 pp. Illinois Nat. Hist. Surv. Urbana, IL.

e. Management Techniques

1) GREAT I

Information: A total of 21 references regarding management techniques for general fish in the GREAT I Region were compiled and reviewed (Table 25). Most references (5 each) were made for Pool 9 and for the entire region.

Voids: No references were made for Pools 1-3, or Pools 5 and 5A. Only one reference was made for Pools 4 and 6.

Evaluation: Most references concerned with general fish management techniques in GREAT I dealt with some aspect of gear evaluation or sampling techniques. Cleary (1959) evaluated electroshocking as a collection device and concluded that its effectiveness depended on water temperature. Grunwald (1978) described a gear modification to allow fish sampling in deep water by electroshocking. Finke (1964) demonstrated that bottom trawling was ineffective as a sampling method in Lake Pepin because of bottom snagging. Greenbank (1974) and Fernholz (1977) assessed fish movements under ice cover.

Jergens (1959) and Kelley and Greenbank (1947), however, largely discussed fish population structure in particular locations, while Helms (1969) demonstrated how fish habitats are affected by water level changes. Strodtman (1940) described stranded fish rescue operations.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Cleary, R. 1959. Summary of investigational shocking on the Mississippi River in the vicinity of Lansing, Iowa, 1958. Iowa Cons. Comm. Quart. Biol. Repts. 11(4):12-18.

Fernholz, W. 1977. Winter sonar scanning - Pool 7, Mississippi River. Wis. Dept. Nat. Res., Fish. Div. 1976-77. Sum. Rept. No. 2. 2 pp.

Finke, A. 1964. Three years of trawling in Lake Pepin, 1961-1963. Wisc. Cons. Dept., West Central Area. Invest. Memo. No. 19. Mimeo. unpublished. 19 pp.

Greenbank, J. 1947. Movement of fish under ice. UMRCC Invest. Rept. No. 13. 13 pp.

Grunwald, G. 1978. Modification of alternating current electrofishing gear for deep water sampling. Minn. Dept. Nat. Res., Fish Mgmt. Rept. No. 10. 12 pp.

Helms, D. 1969. Projected changes in aquatic habitats of the Mississippi River associated with pool level raises. Iowa Cons. Comm. Quart. Biol. Repts. 21(2):46-58.

Jergens, G. 1959. Mississippi River test netting and electrofishing survey, Wisconsin stations, 1958, Pools 6 and 7. Wis. Cons. Dept., W.C. Area. Invest. Memo. No. 4. Mimeo. unpublished. 25 pp.

Kelley, E. and J. Greenbank. 1947. Census of Miller Lake, a Mississippi River backwater. UMRCC Invest. Rept. No. 11. 12 pp.

Strodtman, L. 1940. Fish rescue work on the Mississippi River. Wis. Cons. Bull. 5(3):15-19.

2) GREAT II

Information: A total of 27 references were reviewed regarding management techniques for general fish in GREAT II (Table 26). Pool 11 was referenced most often.

Voids: No references were found for Pools 20-22.

Evaluation: Surber (1929) discussed the use of sloughs as fish culture areas; and Strodtman (1940) described stranded fish rescue operations. Otherwise, nearly all the references regarding general fish management techniques in GREAT III were concerned with the impacts of habitat alterations on fish populations (Helms 1968, 1969; Ackerman et al. 1977; U.S. Army Corps of Engineers 1977, 1978).

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Ackerman, G., P. Koehn, and B. Persen. 1977. Prealteration study of the fishery and morphology of Cassville Slough. Pool 11, River mile 608.6 to 615.1. Iowa Cons. Comm. Proj. No. 77-II-C-15. pp. 99-108.

Helms, D. 1968. Aquatic habitat of the Mississippi River bordering Iowa. Iowa Cons. Comm. Quart. Biol. Repts. 20(4):11-14.

________________. 1969. Projected changes in aquatic habitats of the Mississippi River associated with pool level raises. Iowa Cons. Comm. Quart. Biol. Repts. 21(2):46-58.

Strodtman, L. 1940. Fish rescue work on the Mississippi River. Wisc. Cons. Bull. 5(3):15-19.

Surber, E. 1929. The utilization of sloughs in the Upper Mississippi Wildlife and Fish refuge as fish ponds. Trans. Am. Fish. Soc. 59:106-113.

U.S. Army Corps of Engineers, Army Engineer District, Chicago, Rock Island and St. Paul. 1977. Draft: summary report of fish and wildlife habitat changes resulting from construction of a nine-foot channel in the Upper Mississippi River, Minnesota River, St. Croix River and Illinois Waterway. Chicago, IL. Various pagings.

________________. North Central. 1978. Summary report of fish and wildlife habitat changes resulting from construction of a nine-foot channel in the Upper Mississippi River, Minnesota River, St. Croix River and Illinois Waterway. Chicago, IL. Various pagings.

3) GREAT III

Information: One reference regarding management techniques of general fish was made for the GREAT III Region; it was from the Lower Stretch (Table 27). Ten references regarding this subject were made concerning the entire Upper Mississippi River.

Voids: No references were made regarding management techniques of general fish in Pools 24-26, and only one reference was made for the Lower Stretch.

Evaluation: The U.S. Army Corps of Engineers (1976) indentified and acknowledged the extreme modification and destruction of fish habitat which has occurred in the Lower Stretch as a result of the nine-foot navigation project.

Although Bertrand and Dunham (1972) and DeCook (1960) discuss gear evaluations and Christenson (1948) describes the evaluation of a fish population in a backwater, most references concerning management techniques dealt with some aspect of the evaluation (Nord 1960, U.S. Department of Commerce 1931), overview (Ives and Walter 1977; Upper Mississippi Basin Comprehensive Basin Study Coordinating Committee 1970), or management philosophy (Greenbank 1948) of the fishery resource of the Upper Mississippi River.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Bertrand, B. and L. Dunham. 1972. Efficiency of four fish sampling devices at seven stations on the Mississippi River in August and September 1972. Illinois Dept. Cons., Div. of Fisheries.

Christenson, L. 1948. Preliminary report of Mississippi River backwater fish poisoning operations - 1948. UMRCC Invest. Rept. No. 26. 7 pp.

De Cook, R. and R. Cleary. 1960. Fishing gear evaluation, Mississippi River 1960. Iowa Cons. Comm. Mimeo. unpublished. 5 pp.

Greenbank, J. 1948. Proposed management recommendations. UMRCC Invest. Rept. No. 23. 10 pp.

Ives, J. and W. Walter. 1977. Biological problems of Level B, Main Stem, Upper Mississippi River. UMRCC. Twin Cities, MN. 8 pp.

Nord, R. 1960. 700 miles of river fishing. The Conservation Volunteer. Minn. Dept. Cons. March-April:15-18.

U.S. Army Corps of Engineers, Army Engineer District, St. Louis. 1976. Mississippi River between the Ohio and Missouri Rivers regulating works; final environmental statement. St. Louis, MO. 342 pp.

U.S. Department of Commerce. Fisheries Bureau. 1931. Survey of conditions affecting fisheries on the Upper Mississippi River. Fish. Circ. No. 5. September, 1931.

Upper Mississippi River Basin Comprehensive Basin Study Coordinating Committee. 1970. Upper Mississippi River comprehensive basin study. Appendix L: fish and wildlife. Chicago, IL. 103 pp.

f. Taxonomy

1) GREAT I

For the discussion of taxonomy of general fish, all three GREAT Regions have been combined.

Information: A total of 22 references were reviewed regarding the taxonomy of general fish for all of the GREAT Regions and the Upper Mississippi River (Tables 25-27). Eight were from the entire GREAT I; ten from the entire GREAT II and four from the entire GREAT III.

Voids: No references were made specific to any of the pools of any GREAT Region.

Evaluation: References included in this category are primarily checklists of fishes in various reaches of the Upper Mississippi River (Bailey 1951, Smith 1965) and identification guides (Smith 1978, Harland and Speaker 1969).

Recommendations: It is suggested that it would be valuable to have one or more reference documents which deals with the taxonomy and identification of all fishes in the Upper Mississippi River, particularly if information regarding the distribution, abundance, ecology, and life history characteristics can be included. These documents should be available for both lay and scientific audiences. It is recommended that individuals or research organizations be encouraged or directly supportive to produce this material.

Literature Cited:

Bailey, R. 1951. A checklist of the fishes of Iowa, with keys for identification. In: Iowa fish and fishing, by J. R. Harlan and E. B. Speaker. Iowa Cons. Comm. pp. 187-238, 9 figs.

Harlan, J. and E. Speaker. 1969. Iowa fish and fishing. 4th Ed. Iowa Cons. Comm., Des Moines, IA. 365 pp.

Smith, P. 1965. A preliminary annotated list of the lampreys and fishes of Illinois. Illinois Nat. Hist. Surv. Biol. Notes No. 54. 12 pp.

__________. 1978. The fishes of Illinois. Univ. Illinois Press. Urbana. 304 pp.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

g. Diseases and Anomolies

1) GREAT I

For the discussion of diseases and anomolies of general fish, all three GREAT Regions have been combined.

Information: A total of 15 references were reviewed concerning diseases and anomolies of general fish for all of the GREAT Regions and the Upper Mississippi River. Of these, eight were from Pool 14 (Tables 275-27).

Voids: No references were made for Pools 1-5A; 8-13; 15-18; 20-26, or the Lower Stretch.

Evaluation: Most references concerning diseases and anomolies of general fish resulted from a series of environmental monitoring studies which included reports of observations of fish diseases and anomolies (NALCO Environmental Sciences, 1977). Jergens (1959) and Hubley (1961) reported the incidence of lamprey scarring on fish in different reaches of the Upper Mississippi River; and Hubley (1961) concluded that the incidence was insignificant. Wilson (1916) and Wenke (1968) discussed the incidence of parasites of Upper Mississippi River fishes.

Recommendations: See Recommendations for 1. Sport Fish, 2. Commercial Fish, and 3. Forage Fish.

Literature Cited:

Hubley, R., Jr. 1961. Incidence of lamprey scarring of fish in the Upper Mississippi River, 1956-58. Trans. Am. Fish. Soc. 90(1):83-85.

Jergens, G. 1959. Mississippi River test netting and electrofishing survey, Wisconsin stations, 1958, Pools 6 and 7. Wis. Cons. Dept., W. C. Area. Invest. Memo. No. 4. Mimeo. unpublished. 25 pp.

NALCO Environmental Sciences. 1977. R. Gerhold, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

Wenke, T. 1968. Abundance of Crepidostomum and other intestinal helminths in fishes from Pool 19, Mississippi River. Iowa State J. Sci. 43(2):211-222.

Wilson, C. 1916. Copepod parasites of fresh-water fishes and their economic relations to mussel glochidia. Bull. U.S. Bur. Fish. 34(1914):331-374.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

G. Amphibians and Reptiles

1. GREAT I

The amphibians and reptiles of the GREAT II and III areas will be discussed in conjunction with GREAT I.

Information: A total of 83 citations relating to amphibians and reptiles of the Upper Mississipi River were reviewed (Tables 28-30). Most surveys were conducted in Pools 5-10 of the GREAT I Region and in the Lower Stretch of the GREAT III Region. Some of the studies were conducted with other biological sampling and are general in nature; others were species and pool specific. Many of the publications describe statewide distribution of amphibians and reptiles.

Voids: No information on amphibians and reptiles was available for Pools 1-4, 11-17, 19, 20, and 22-26 (Tables 28-30). Articles which describe amphibians and reptiles from specific states may or may not contain reference to Upper Mississippi River habitats.

Evaluation: Bailey and Speaker (1946) discuss amphibians and reptiles from a culinary aspect describing how snapping turtles and bullfrogs are used as a food source. A general description of sixteen snake species found in Minnesota is provided by Buckmann (1965). The Mississippi River Work Unit (1976, 1977, 1978) compiled reports of studies done in Pools 7, 8 and 9 which provide more location specific data on leopard frogs. Cochran (1977) conducted a study of feeding habits and length-weight relationships of spiny softshell turtles in Pools 5, 5A and 6. This kind of information is valuable in determining habitat preferences so that these areas are not destroyed. The habitat as well as predators of the soft-shelled turtle, Trionyx sp., was also studied by James (1966). He determined that large permanent water

bodies with sand or muddy bottoms and sandy beaches were preferred by Trionyx sp. Terpening et al. (1974) studied the stretch of the Mississippi River from St. Louis, Missouri to Cairo, Illinois. This is an excellent publication which discusses amphibians and reptiles observed. The number of species of amphibians and reptiles observed or captured per land cover type is discussed in detail. Several methods were used to observe or collect herpetofauna. During spring, choruses of breeding amphibians were identified when possible to species. Amphibian eggs were collected, hatched, and the tadpoles identified. Amphibians and reptiles have been discussed in general for the states bordering the Upper Mississippi River by Breckenridge (1944), Briggs (1975), Cahn (1937), Hurter (1911), Lueth (1941), O'Donnell (1937), and Smith (1961). Each of these publications provides extensive information on each species occurring in the state. Studies by Blanchard (1924), Cagle (1942a,b), Garman (1889), Hurter (1893), and Owens (1941) were localized in southern Illinois and Missouri, and are more relevant to the GREAT II and III Regions. These articles furnish more pertinent information on distribution and habitat of amphibians and reptiles of the Upper Mississippi River region. The U.S. Department of the Interior (1970) has compiled a list of amphibians and reptiles inhabiting the Upper Mississippi River Wildlife and Fish Refuge near Winona, Minnesota. Another study by Bruton (1971) reported on the amphibians on two islands in the Mississippi River near Monticello, Minnesota. A biological survey which included turtles was conducted near river mile 424.5 (Pool 18) by Baker Group (1970). Two publications (Burt and Burt 1929, Minton and Minton 1948) which are not as detailed as those previously mentioned discuss amphibians and reptiles from the Mississippi Valley.

Recommendations: A comprehensive survey of amphibians and reptiles should be combined with a complete biological sampling program in

specific areas of the river where habitat disturbances may be expected. A study of food habits and breeding areas should be included. A follow-up study should be conducted to determine if any man-induced disturbances have changed the habitat and subsequent distribution of any species.

Literature Cited:

Bailey, R. M. and E. B. Speaker. 1946. Fisheries of Iowa. In: Wildlife Resources of Iowa. The State of Iowa, Des Moines. 41 pp.

Baker Group. 1970. Ecology final report. Biol. 317.

Blanchard, F. N. 1924. A collection of amphibians and reptiles from southeastern Missouri and southern Illinois. Mich. Acad. Sci., Arts and Letters Papers. 4: 533-41.

Breckenridge, W. J. 1944. Reptiles and amphibians of Minnesota. Univ. of Minnesota Press, Minneapolis. xiii + 202 pp.

Briggs, J. L. 1975. Key to the herpetofauna of Wisconsin. Milwaukee Public Museum, Milwaukee. 29 pp.

Bruton, C. 1971. The amphibians on two islands in the Mississippi River at Monticello, Minnesota. Unpublished report, St. Cloud State College.

Buckmann, C. A. 1965. Our sixteen serpents. The Conservation Volunteer. Minnesota Dept. Cons. May - June. p. 30-36.

Burt, C. E. and M. D. Burt. 1929. A collection of amphibians and reptiles from the Mississippi Valley, with field observations. Am. Mus. Novitates 381. 14 pp.

Cagle, F. R. 1942a. Herpetological fauna of Jackson and Union counties, Illinois. Am. Midl. Nat. 28(1): 164-200.

__________. 1942b. Turtle populations in southern Illinois. Copeia. 1942 (3): 155-62.

Cahn, A. R. 1937. The turtles of Illinois. Ill. Biol. Monog. 16(1-2). 218 pp.

Cochran, P. A. 1977. Feeding habits and length-weight relationships in spiny softshell turtles from selected areas in Pool 5, 5A and 6 of the Upper Mississippi River. Pap. Pres. at Miss. River. Res. Consort., Winona, MN. June 8-10, 1977.

Garman, H. 1889. A preliminary report on the animals of the waters of the Miss. bottoms near Quincy, Illinois, in August, 1888. Part I. Ill. Lab. Nat. Hist. Bul. 3(9): 123-84.

Hurter, J. 1893. Catalogue of reptiles and batrachians found in the vicinity of St. Louis, Mo. St. Louis Acad. Sci. Trans. 6(11): 251-61.

__________. 1911. Herpetology of Missouri. St. Louis Acad. Sci. Trans. 20(5): 59-274.

James, J. E. 1966. Biology of the soft-shelled turtle, Trionyx, sp., of the Upper Mississippi River. M.S. Thesis (education), Winona State College, Winona, MN. 29 pp.

Lueth, F. X. 1941. Manual of Illinois snakes. Ill. Dept. Cons., Springfield. 48 pp.

Minton, S. A., Jr. and J. E. Minton, 1948. Notes on a herpetological collection from the Middle Mississippi Valley. Am. Midl. Nat. 40(2): 378-90.

Mississippi River Work Unit. 1976. Mississippi River Work Unit Accomplishment Report 1975-76. Wis. Dept. Nat. Res., La Crosse. Unpublished

__________. 1977. Mississippi River Work Unit Annual Report 1976-1977. Wis. Dept. Nat. Res., La Crosse. Unpublished.

__________. 1978. Mississippi River Work Unit Annual Report 1977-1978. Wis. Dept. Nat Res., La Crosse. Unpublished.

O'Donnell, D. J. 1937. Natural history of the ambystomid salamanders of Illinois. Am. Midl. Nat. 18(6): 1063-71.

Owens, D. W. 1941. Some amphibians and reptiles from southern Ill. Copeia 1941 (3): 183-4.

Smith, P. W. 1961. The amphibians and reptiles of Illinois. Ill. Nat. Hist. Surv. Bull. 28(1) November. 298 pp.

Terpening, V. A., L. J. Hunt, P. K. Evans, S. J. Bleiweiss and R. C. Zoanetti. 1974. A survey of the fauna and flora occurring in the Mississippi River floodplain between St. Louis, Missouri, and Cairo, Illinois. U.S. Dept. Army. Contract Report Y-74-3. 391 pp..

U.S. Department of the Interior. 1970. Amphibians and reptiles of the Upper Mississippi River Wildlife and Fish Refuge. Bur. Sport. Fish and Wildl. leaflet 420.

H. Birds

1. GREAT I

The discussion of birds for all three GREAT Regions will be combined.

a. Waterfowl

1) Nesting and Rearing

Information: Seven articles or publications pertaining to nesting and rearing of waterfowl species were available (Tables 31-33). Four publications are broadly based discussions of waterfowl; two books concern waterfowl species. A fifth publication is of little use because of its non-specific nature and orientation toward hunting.

The remaining two articles are descriptions of waterfowl productivity studies to be conducted in Pools 4 through 11 on spoil disposal sites.

Voids: Detailed information on nesting requirements and behavior of waterfowl on the Mississippi River is not available. Aside from the proposed productivity studies in Pool 4-11, there have been no single site studies to determine habitat values for nesting, annual bird production, or behavior of nesting birds and their young.

Evaluation: Musgrove (1977) has discussed each waterfowl species occurring in Iowa and examines breeding ranges, nest site characteristics, number and appearance of eggs, and describes the downy young. Heintzelman (1978) and Johnsgard (1975) provide similar information for waterfowl occurring throughout North America. These accounts are applicable to all portions of the Upper Mississippi River because of the broad distribution and high mobility of most waterfowl species.

The waterfowl productivity studies to be conducted in Pools 4-11 by the Wisconsin Department of Natural Resources (DNR) (1977,1978) should provide valuable information on nesting waterfowl in these areas.

Recommendations: No further work should be initated without reference to the Wisconsin DNR results from Pool 4-11. These studies are likely to identify areas of concern that might merit further examination.

Mapping of appropriate waterfowl nesting habitat in this region would be useful as a first step in determining the status and monitoring the future of waterfowl productivity on the Upper Mississippi River.

Literature Cited:

Heintzelman, D. S. 1978. North American ducks, geese and swans. Winchester Press, N. Y.

Johnsgard, P. A. 1975. Waterfowl of North America. Indiana Univ. Press.

Mississippi River Work Unit. 1977. Annual Report 1976-77. Wisconsin Dept. Nat. Resources, La Crosse.

____________. 1978. Annual Report 1977-78. Wisconsin Dept. Nat. Resources, La Crosse.

Musgrove, J. W. 1977. Waterfowl in Iowa. State of Iowa, Des Moines. 130 pp.

2) Feeding

Information: Twenty articles containing information on waterfowl food or feeding behavior were available (Tables 31-33). Fifteen of these deal with specific pools or sections of the river; the remainder discuss particular species or food sources. References to pools were limited to Pools 5, 7, 8, 9, and 19, although two additional articles concern broader extents of the river such as the Upper Mississippi Wildlife Refuge (Pools 3-14).

Voids: Site specific information is limited to only a few pools. The available information varies in detail and comprehensiveness.

Evaluation: The Mississippi River Work Unit (Nicklaus and Merz, 1976, MRWU 1976, 1977) has examined diving duck food in Pools 7,8 and 9 for four consecutive years; and Anderson (1976) studied waterfowl food sources at Pools 5 and 7. Pool 19 has been examined quite intensively by several investigators (Thompson et al. undated, Thompson, 1969, Thornburg 1973). Uhler (1928) presents an analysis of waterfowl food on the Upper Mississippi River Wildlife Refuge, and Shatford (1978) discusses similar information for the Upper Mississippi River Wildlife Management Area above St. Louis.

The food habits of swans and scaup have been studied by Limpert and Vose (1976) and Rogers and Korschgen (1966) respectively. The food of migratory ducks in Illinois was examined by Anderson (1959).

All of the studies cited above are relatively detailed and provide a good picture of food availability and the preferences of waterfowl species. Although most of the information is limited to a few sites, it may be generalized for other sections of the river where similar conditions exist.

Recommendations: When possible, site studies of benthos, aquatic macrophytes, and fish should be correlated with associated

breeding migratory and wintering waterfowl populations. Studies of this sort should be especially valuable in assessing the basis of impact of proposed river alterations on waterfowl.

Literature Cited:

Anderson, H. G. 1959. Food habits of migratory ducks in Illinois. Ill. Nat. Hist. Surv. Bull. 27:289-344.

__________. 1976. Causes of decreased migrant waterfowl use is part of the Upper Mississippi River Wildlife and Fish Refuge. M.S. Thesis. Univ. Wisconsin, Stevens Point. 63 pp.

Limpert, R. and R. Vose. 1976. Fall feeding habits of migrating whistling swans on the Upper Mississippi River. Submitted to Wildl. Mgmt. Jan. 1976.

Mississippi Rivers Work Unit. 1976. Accomplishment Report 1975-76. Wis. Dept. Nat. Res., La Crosse. Unpubl.

__________. 1977. Accomplishment Report 1976-77. Wisc. Dept. Nat. Res., La Crosse. Unpubl.

Nicklaus, R. A. and E. M. Merz. 1976. An assessment of diving duck food resources in the Mississippi River Navigation Pool 7 and selected areas of Pools 8 and 9. Wis. Dept. Nat. Res., La Crosse.

Rogers, J. P. and L. J. Korschgen. 1966. Food habits of lesser scaup or breeding, migration, and wintering areas. J. Wildl. Mgmt. 30:258-264.

Shatford, J. 1978. Annual narrative report. Upper Mississippi Wildlife Management Area. Missouri Dept. Cons. 15 pp.

Thompson, D. H. 1969. Feeding behavior of diving ducks on Keokuk Pool, Mississippi River. M.S. Thesis. Iowa St. Univ. of Sci. and Tech., Ames.

Thompson, J. D. and W. F. Gale. No date. Feeding ecology of diving ducks of Keokuk Pool, Mississippi River. (ms. for J. Wildl. Mgmt.)

Thornburg, D. D. 1971. Flock behavior of diving ducks on Keokuk Pool, Mississippi River. M. S. Thesis. Iowa St. Univ., Ames.

__________. 1973. Diving duck movements on Keokuk Pool, Mississippi River. J. Wildl. Mgmt. 37:382-389.

Uhler, F. M. 1928. General report on biological features of the Upper Mississippi Wildlife and Fish Refuge. Fishery Mgmt. Serv. Off. (1965), La Crosse, Wisc. 122 pp.

3) Distribution and Abundance

Information: Twenty-eight articles concerning waterfowl distribution and abundance in the Upper Mississippi River Region were reviewed (Tables 31-33). The majority of these were population censuses, with most based on hunters' harvests. Five articles dealt with specific pools and the remainder were regional, encompassing a particular state or section of the river, or generalized for the entire Mississippi River Flyway.

Voids: There are no significant voids in the data concerning the distribution and abundance of waterfowl. However, most of these data are not site specific. In addition, waterfowl numbers and presence fluctuate annually because of hunting pressure, disease, weather, etc., and censuses made one year may not be applicable in predicting trends in subsequent years.

Evaluation: Site specific studies have been conducted by Andersen (1976) at Pools 5 and 7 and Thornburg (1971, 1973) at Pool 19. Both these studies are particularly valuable because collateral information on food and behavior is available for each of the pools.

A book by McKane (1969) discusses the ducks of the Mississippi Flyway. Other books which provide general information are those by Heintzelman (1978) and Johnsgard (1975).

The remaining literature is confined to censuses published primarily by state or federal game agencies. Historical perspectives of waterfowl populations in the Mississippi Flyway are available in two publications (Connnett 1949, Green 1963).

Recommendations: The location of important nesting and wintering areas should be catalogued from the existing literature and data available from state agencies.

Site studies will be necessary whenever an area becomes of interest due to actual or potential changes in resources. Whenever possible, studies of waterfowl populations should be accompanied by evaluations of food, habitat, disturbance, etc. Knowledge of these parameters is necessary to fully evaluate the status of waterfowl in a particular area.

Literature Cited:

Anderson, M. L. 1976. Causes of decreased migrant waterfowl use in part of the Upper Mississippi Fish and Wildlife Refuge. M.S. Thesis, Univ. Wisconsin, Stevens Point. 63 pp.

Connett, E. V. (ed.) 1949. Wildfowling in the Mississippi flyway. D. Van Nostrend Co., Inc., New York. 387 pp.

Green, W. E. 1963. Waterfowl utilization and hunting kill 1946-1960. Upper Mississippi Wildlife and Fish Refuge. USDI Bur. Sport Fish. and Wildl. Spec. Rept. No. 71.

Heintzelman, D. S. 1978. North American ducks, geese, and swans. Winchester Press, N. Y.

Johnsgard, P. A. 1975. Waterfowl of North America. Indiana Univ. Press.

McKane, J. 1969. Ducks of the Mississippi Flyway. North Star Press, St. Cloud, Minn.

Thornburg, D. D. 1971. Flock behavior of diving ducks on Keokuk Pool, Mississippi River. M.S. Thesis, Iowa St. Univ. Ames.

______________. 1973. Diving duck movements on Keokuk Pool, Mississippi River. J. Wildl. Mgmt. 37:382-389.

4) Habitat

Information: Information relating to waterfowl habitat was found in 11 publications (Tables 31-33). One (Fremling 1977) discusses the importance of backwater habitat in Pool 7 and three are statewide descriptions of waterfowl species and their preferred habitats in Minnesota (Jessen 1970), Iowa (Musgrove 1977) and Illinois (Arthur and Kennedy 1972). Two additional references are environmental assessments that consider waterfowl populations and habitat (Fremling 1977, Fremling et al. 1976). Books by McKane (1969), Heintzelman (1978), and Johnsgard (1975), provide general information on waterfowl habitat of the Mississippi River Flyway and North America.

Voids: There have been little or no quantitative analyses of habitat features that are important to waterfowl. These features include vegetation structure, food resources, shelter from weather or disturbance, etc. Although there is a general awareness of the habitat types preferred by most species, the critical parameters which determine nesting success or winter survival have rarely been identified.

Evaluation: Two papers provide relatively complete discussions of habitat in specific pools. In Pool 5 (Fremling et al. 1976), waterfowl food and habitat resources were examined. The importance of backwater habitats in Pool 7 was also examined (Fremling 1977). The analyses of waterfowl habitat in environmental impact statements tends to be generalized although they may provide an estimation of the extent of appropriate habitat available.

Good statewide and regional studies of waterfowl habitats are available from Musgrove (1977), Johnsgard (1975), and Heintzelman (1978). These may be especially useful because species accounts include information on nesting, feeding and distribution as well as habitat requirements.

Recommendations: A census of important waterfowl habitat areas is a first step in evaluating the status and future of waterfowl populations in the Upper Mississippi River Region. After this has been done, site-specific studies should be conducted to analyze the critical features to which the birds are responding.

Literature Cited:

Arthur, G. L. and D. D. Kennedy. 1972. Illinois waterfowl survey permanent site waterfowl trap. Ill. Dep. Cons. W-043-R/W/SP1.

Fremling, C. R. 1977. Mississippi River. 1977. A paper presented at the annual meeting of Upper Mississippi River Research Consortium, June 1, 1977. Winona St. Univ. 5 pp.

Fremling, C. R., D. N. Nielsen, E. R. McConville and R. N. Vose. 1976. Aquatic plants In: The Weaver Bottoms: a field model for the rehabilitation of backwater areas of the Upper Mississippi River by modification of standard channel maintenance practices. Final report to the U.S. Army Corps of Eng., St. Paul District. DACW37-75-C-0193 and DACW37-75-C-0194. 52 pp.

Heintzelman, D. S. 1978. North American ducks, geese, and swans. Winchester Press, N.Y.

Jessen, R. L. 1979. Mallard population trends and hunting losses in Minnesota. J. Wild. Mgmt. 34:93-105.

Johnsgard, P. A. 1975. Waterfowl of North America. Indiana Univ. Press.

McKane, J. 1969. Ducks of the Mississippi Flyway. North Star Press, St. Cloud, MN.

Musgrove, J. W. 1977. Waterfowl in Iowa. State of Iowa, Des Moines. 130 pp.

5) Management Techniques

Information: Ten articles relating to waterfowl management were available (Tables 31-33). Eight of these dealt exclusively with hunting. The remaining two examined causes of nonhunting mortality.

Voids: No articles were available which discuss habitat enhancement or other positive management programs. These may be available through state of federal agencies.

Evaluation: Three publications (Nicklaus 1975, 1976, 1977) provide data on consecutive years of waterfowl harvest in Minnesota-Wisconsin. An article (Green 1963) from the Bureau of Sport Fisheries and Wildlife provides a good analysis of hunting harvest between 1946 and 1960. The remaining references are of limited value in examining population trends.

Recommendations: Generalized information obtained from site studies should be applicable to most locations on the Upper Mississippi River because most waterfowl species are highly mobile and have broad ranges. However, management recommendations should be based on food, habitat, and predator evaluations in the location of interest.

Literature Cited:

Green, W E. 1963. Waterfowl utilization and hunting kill 1946-1960. Upper Mississippi River Wildlife and Fish Refuge. USDI Bur. Sport Fish and Wildl. Spec. Rept. No. 71.

Nicklaus, R. H. 1975. A summary of 1974 waterfowl harvest parameters on the Mississippi River portions of Minnesota and Wisconsin. Wisc. Dept. Nat. Res., La Crosse.

__________. 1976. A summary of 1975 waterfowl harvest on the Mississippi River portions of Minnesota and Wisconsin. Wisc. Dept. Nat. Res., La Crosse.

__________. 1977. A summary of 1976 waterfowl harvest parameters on the Mississippi River portions of Minnesota and Wisconsin. Wisc. Dept. Nat. Res., La Crosse.

b. Waterbirds

Information: Eleven publications dealing with waterbirds were reviewed (Tables 34-36). Four of these contain information on waterfowl and are discussed in that section. Five papers are censuses of herons in the lower stretch of the Upper Mississippi River. Another is a directory to heron, egret, and cormorant rookeries.

Voids: No comprehensive census of waterbirds on the Upper Mississippi River is available. Species accounts of food, nesting, and habitat requirements are also lacking.

Evaluation: The directory to rookeries by Nicklaus (1977) is a valuable source for determining important nesting areas of herons, egrets and cormorants. The directory is divided by pool and provides information on rookery size, status, dominant tree species, and land ownership.

Heron censuses by Graber (1973-1977) may be valuable in assessing population trends of herons in the lower reaches of the Upper Mississippi River.

A final article discusses the status of the Least Tern in the Mississippi River Valley (Hardy 1977).

Recommendations: The 1977 study of rookeries should be repeated at frequent intervals to determine the status of these areas. More intensive studies of stable and declining areas would be valuable in assessing reasons for decline and possible mitigation procedures.

Literature Cited:

Graber, R. R. 1973. Mississippi River heron census. Ill. Nat. Hist. Surv. report to Waterways Expt. Sta. 4 pp.

__________. 1974. Mississippi River heron census II. Ill. Nat. Hist. Surv. report to Waterways Expt. Sta. 5 pp.

__________. 1975. Mississippi River heron census III. Ill. Nat. Hist. Surv. report to Waterways Expt. Sta. 5 pp.

__________. 1976. Mississippi River heron census IV. with comments on the Least Tern). Rept. to U.S. Army Corps. of Engr., St. Louis District. 4 pp.

__________. 1977. Mississippi River heron census V. Ill. Nat. Hist. Surv. report to U.S. Army Corps of Eng., St. Louis, District. 4 pp.

Hardy, J. W. 1957. Least Tern in the Mississippi Valley. Mich. St. Univ. Mus. 1:1-60.

Nicklaus, R. H. 1977. Heron-Egret-Cormorant rookery directory. Upper Mississippi Conservation Committee. *Wildlife Technical Section.*

2. GREAT II

See 1. GREAT I.

3. GREAT III

See 1. GREAT I.

I. Mammals

1. GREAT I

The discussion of mammals of all three GREAT Regions have been combined.

Information: Thirteen articles relating specifically to mammals were reviewed (Tables 34-36); however more general information exists and is discussed in the following section (see J. General Wildlife).

Voids: Except for a study near Winona, Minnesota there have been no single species studies of mammals in the Upper Mississippi River Region. Most existent studies represent analyses of distribution and abundance, primarily of game or fur-bearing animals. The behavior, food, habitat requirements and sensitivity to disturbance of the mammals associated with the river are generally poorly known.

Evaluation: State summaries of mammal species provide the most detailed information available for the Mississippi River area. These include books by Bowles (1975) (Iowa), Schwartz and Schwartz (1959) (Missouri), and Gunderson and Beer (1953) (Minnesota). A publication by Bennitt (1937) surveys the resident game and furbearers of Missouri. The U.S. Dept. of Interior has also published a list of mammals of the Upper Mississippi River Wildlife Refuge (1968).

Mammal movement and distribution was examined in an environmental impact study on Pool 12 (Cawley 1978) as well as in a study of white-tailed deer near Winona, Minnesota by Mattison and Leinecke (1972). A study of mammals of the Mississippi bottoms near Quincy in 1888 (Garman 1890) provides an interesting historical perspective.

Other studies are of limited application and include the discovery of a prehistoric mammal skull (Galbreath 1974) and mammals as intermediate hosts in mosquito lifecycles (Hayes 1973).

Recommendations: Habitat for mammal species in the river basin should be analyzed and catalogued and its status determined. The effects of navigation and habitat alteration (levees, dredge spoils, etc.) should be determined, especially for semi-aquatic species such as beaver and muskrat.

Literature Cited:

Bennitt, R. 1937. A survey of the resident game and furbearers of Missouri. Univ. Mo. Studies 12:1-215.

Bowles, J. B. 1975. Distribution and biogeography of mammals of Iowa. Spec. Publ. No. 9, Museum, Texas Tech. Univ.

Cawley, E. T. 1978. Biological impacts study of winter navigation, Pool 12, Upper Mississippi River. Loras College, Environ. Res. Center. Dubuque, IA. 14 pp.

Galbreath, E. L. 1974. A cranium of symboscavitrous mammalia from the Mississippi River between southern Illinois and Missouri. USA Trans. Ill. St. Acad. Sci. 67:393-396

Garman, J. 1890. A preliminary report on the animals of the Mississippi bottoms near Quincy, Illinois in August, 1888. Part I. Ill. Nat. Hist. Bull. 3:123-184.

Gunderson, H. L. and J. R. Beer. 1953. The mammals of Minnesota. Univ. Minn. Press, Minneapolis.

Hayes, J. 1973. Overwinterizing *Culex pipiens pipiens* in the Ohio-Mississippi River basin, 1962-67. Mosq. News. 33:424-428.

Mattison, W. M. and J. F. Leinecke. 1972. A radiotelemetric study of the behavioral and ecology of white tailed deer in the Upper Mississippi River flood plain environment. M.S. Thesis, St. Mary's College, Winona, MN.

Schwartz, C. W. and E. R. Schwartz. 1959. The wild mammals of Missouri. Univ. Mo. Press.

U.S. Dept. of the Interior. 1968. Mammals of the Upper Mississippi River Wildlife and Fish Refuge. Bus. Sport Fish. and Wildl. Leaflet. 326 pp.

2. GREAT II

See 1. GREAT I.

3. GREAT III

See 1. GREAT I.

J. General Wildlife

1. GREAT I.

The discussion of General Wildlife for all three GREAT Regions will be combined.

Information: One hundred-ten articles discuss birds and mammals or wildlife in general (Tables 34-36). Approximately half of these are environmental impact statements which contain variable degrees of detail regarding specific pools, faunal species, and habitats. Twelve additional publications concern individual pools or series of pools.

Voids: It is difficult to assess the completeness of information available; however, it appears that the fauna of the entire Upper Mississippi River Region has been examined, at least on a superficial level, through environmental impact studies, agency studies and scientific studies. No significant voids are apparent.

Evaluation: The majority of environmental impact studies were conducted by the U.S. Army Corps of Engineers in association with the proposed 9 and 12 foot channels and local dredging or levee construction; these statements cover the entire Upper Mississippi River System. Environmental studies are also available for most individual pools. These studies usually include presence and abundance of wildlife species as well as habitat descriptions. Reports of this type can provide valuable information on local fauna but are frequently limited by lack of quantitative data or short study time spans.

Studies of Individual Pools

Pool 1 - Wildlife in the Twin Cities area is discussed in two publications; one by Dodge et al. (1972) provides a list of birds of Min-

neapolis - St. Paul. The other (U.S. Fish and Wildlife Service 1976) examines all wildlife species of the area. Four environmental impact statements (EIS) are available for Pool 1 (Collingsworth 1973a, 1973b, Collingsworth et al. 1973, U.S. Army Corps of Engineers 1973).

Pool 2 - No general studies have been conducted on Pool 2 although two EIS are available (Collingsworth 1973b, Collingsworth et al. 1973).

Pool 3 - Pool 3 is discussed in one EIS (Miller et al. 1973).

Pool 4 - Game species of Lake Pepin are examined in one report (Minn. Dept. Cons. 1964).

Pool 5 - Fremling et al. (1973) presents an analysis of terrestrial animals and habitat for Pool 5. There is also one environmental monitoring report (Northern States Power Company 1968-69).

Pool 6 - No specific information.

Pool 7 - A publication by Fremling et al. (1976) examines the wildlife of Weaver Bottoms, and Miller (1976) discusses wildlife and habitat in the same area.

Pool 8 - Two environmental assessment or impact studies have been conducted in this pool (Claflin 1973, Held 1975). In addition, Greenbank (1946, 1947) provides an important analysis of the effect of drawdown on wildlife.

Pool 9 - No specific information.

Pool 10 - Environmental impact studies have been conducted at Prairie du Chien, Wisconsin (Federal Highway Administration 1971) and Guttenberg, Iowa (U.S. Army Corps of Engineers 1974).

Pool 11-14 - No specific information.

Pool 15 - Environmental impact studies have been reported for Quad-Cities by Lewis (1977).

Pool 16-18 - No specific studies.

Pool 19 - Two environmental impact studies (U.S. Army Corps of Engineers 1971a, 1976) have been conducted in the Keokuk Iowa area. An additional paper (Anonymous 1972) examines wildlife habitat in the area.

Pool 20 - No specific studies.

Pool 21 - Habitats of Pool 21 have been described in one publication (Ostdiek et al. 1971).

Pool 22 - No specific studies.

Pool 24-26 - These pools have been described in two environmental impact publications (U.S. Army Corps of Engineers. 1975, USDI 1977). One of these (U.S. Army Corps of Engineers 1975) provides extensive analysis of wildlife species and their associated habitats for this river section. Solomon et al. (1975) presents an animal inventory of these three pools.

Lower Stretch - Two environmental studies are available for the Lower Stretch of the Upper Mississippi River (Johnson et al. 1974, Emge 1972). Terpening et al. (1974, 1975) provide faunal surveys of the region.

More comprehensive studies are available through a number of reports and publications. Particularly valuable is a bibliography of wildlife resources of the Upper Mississippi River by Helms and Boland (1972). A similar scope of information is available from a comprehensive study of terrestrial habitat and wildlife conducted by the Upper Mississippi River Comprehensive Basin Study Coordinating Committee (1970a, 1970b).

Recommendations: Although the general wildlife of the Upper Mississippi River has been superficially examined, there are some pools that have no specific information. The general wildlife of these pools should be studied.

Literature Cited:

Anonymous. 1972. Walton League opposes dredge and fill projects on Upper Mississippi River. Outdoor America. 37:9

Claflin, T. O. 1973. Environmental assessment - navigation Pool 8. Mimeo report to U.S. Army Corps of Eng. River Studies (intr. Univ. Wisc., La Crosse.)

Collingsworth, R. F. 1973a. Final report: environmental impact assessment study, Pool 1, of the northern section of the Upper Mississippi River. No. Star Res. Inst. Minneapolis, MN.

__________. 1973b. Final report: environmental report assessment study, Pool 2, of the northern section of the Upper Mississippi River. No. Star Res. Inst., Minneapolis, MN.

__________. 1973c. Final report: environmental impact assessment study, upper and lower St. Anthony Pools, of the northern section of the Upper Mississippi River. No. Star Res. Inst., Minneapolis, MN.

Collingsworth, R. F., B. J. R. Gudmundson, W. L. K. Schwartz, and C. W. Rudelius. 1973. Environmental impact assessment study: St. Anthony Falls upper and lower pools, Pool 1, Pool 2, and lower 25 miles of the St. Croix and Minnesota rivers. No. Star Res. Inst., Minneapolis, MN.

Dodge, A. W., W. J. Breckenridge, A. F. Fullerton, and D. W. Warner. 1972. The birds of the Minneapolis-St. Paul region. Bell Museum of Nat. Hist. Univ. Minn., Minnesota. 29 pp.

Emge, W. P. 1972. Study plan for an environmental inventory and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri and Cairo, Illinois. USACE Waterways Expt. Stn., Vicksburg, MS. 36 pp.

Federal Highway Administration. 1971. Crawford County, USH 18, Mississippi River crossing, city of Prairie du Chien. Madison, WI. 95 pp.

Fremling, C. R., D. Gray, and D. N. Nielsen. 1973. Phase III. Pool 5 northern section of the Upper Mississippi River Valley. Winona St. Coll., Winona, MN. 298 pp.

Greenbank, J. 1946. Effects of midwinter drawdowns of the Upper Mississippi River on aquatic wildlife. UMRCC Invest. Rept. No. 5, 10 pp.

__________. 1947. Field notes on river drawdown. UMRCC Invest. Rept. No. 10, 1 p.

Held, J. W. 1975. The environmental impact of upland disposal of dredged material at Island 117, navigation Pool 8, Upper Mississippi River. Army Engineer Waterways Expt. Stn. Vicksburg, MS. (Tech. Rept.)

Helms D. R. and T. L. Boland. 1972. Upper Mississippi River natural resources biblography. Upper Mississippi River Conservation Committee. Fish Tech. Section. 62 pp.

Holzer, J. A. and S. J. Ironside. 1977. Basic lake inventory of Lake Onalaska, La Crosse, Wisconsin. Wis. Dept. Nat. Res. Mgmt. Rept. 42 pp.

Holzinger, J. M. 1887. Notes on the Mollusca of Winona County. Ann. Rept. Geol. and Nat. Hist. Surv. May. 6:485-491.

Johnson, J. H., R. C. Solomon, C. R. Bingham, B. K. Colbert, and W. P. Emge. 1974. Environmental analysis and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri and Cairo, Illinois. U.S. Army Engineer Waterways Expt. Stn. Vicksburg, MS. 148 pp.

Lewis, W. M. 1977. Observation on the ecological impact of the Quad-Cities Generating Station. So. Ill. Univ.

Miller, E. F., K. Krum, W. L. K. Schwartz, and W. Rudelius. 1973. Environmental impact assessment study, Pool 3. St. Mary's College, Winona, MN. 192 pp.

Miller, R. C. 1976. Habitat correlation of wildlife to selected emergent vegetation in Weaver Bottoms, Minnesota and Fountain Bay, Wisconsin on the Upper Mississippi River. B.S. Thesis. St. Mary's College, Winona, MN. 64 pp.

Ostdiek, J. L., G. H. Schneider and A. F. Pogge. 1971. Ecological habitats in Pool 21, Upper Mississippi River. Rept. to Army Corps of Eng. No. Central Div., Chicago, IL. 67 p.

Solomon, R. C., D. R. Parsons, D. A. Wright, B. K. Colbert, and L. Ferris. 1975. Environmental inventory assessment of navigation pools 24, 25, and 26, Upper Mississippi and Lower Illinois rivers. Summary Report. Waterways Expt. Stn., Vicksburg, MS. 100 pp.

Terpening, V. A., L. J. Hunt, D. K. Evans, S. J. Beiweiss, and R. L. Zoanetti. 1974. A survey of the fauna and flora occurring in the Mississippi flood plain between St. Louis, Missouri and Cairo, Illinois. Waterways Expt. Stn. 391 pp.

Terpening, V. A., J. R. Nawrot, M. J. Sweet, and D. L. Damrau. 1975. Environmental inventory and assessment of navigation pools 24, 25, and 26, Upper Mississippi and Lower Illinois rivers; floodplain animals and their habitats. So. Ill. Univ., Carbondale Coop. Wildl. Res. Lab. Army Eng. Waterways Expt. Stn., Vicksburg, MS. 285 pp.

U.S. Army Corps of Engineers. 1971a. Navigation project, Mississippi River, Fort Madison, Iowa. Commercial boat harbor. Final environmental impact statement. Army Eng. Distr., Rock Island, IL. 27 pp.

______________. 1971b. Navigation project, Mississippi River, Fort Madison, Iowa. Commercial boat harbor; final environmental statement. Rock Island, Illinois 23 pp. PB-199 450-F. (Tech. Rept.)

______________. 1973. Pigs Eye coal terminal, Mississippi River at St. Paul, Ramsey County, Minnesota. Draft environmental impact statement. Army Engineer Dist., St. Paul, MN. 220 p.

______________. 1974. Draft environmental impact statement: operation and maintenance Upper Mississippi River, head of navigation to Guttenberg, Iowa. U.S. Army Corps of Engineers, St. Paul, MN.

______________. 1975. Operation and maintenance of pools 24, 25, and 26, Mississippi and Illinois Rivers; final environmental statement. St. Louis, MO. 301 pp.

U.S. Dept. of Interior. 1977. Upper Mississippi, a wild and scenic river study, final report and environmental impact statement. Bureau of Reclamation.

U.S. Fish and Wildlife Service. 1976. Fish and wildlife technical report. Prep. for the Fish and Wildlife Task Group. Minneapolis - St. Paul Area Level B Study, UMRCC.

Upper Mississippi River Comprehensive Basin Study Coordinating Committee. 1970a. Upper Mississippi River comprehensive basin study. Main report. Chicago, IL. 133 pp.

______________. 1970b. Upper Mississippi River comprehensive basin study. Appendix L:fish and wildlife.

2. GREAT II

See 1. GREAT I.

3. GREAT III

See 1. GREAT I.

3.2 Man-Induced Impacts on Fish and Wildlife Resources

A. Maintenance/Construction Activities

1. Channels

a. GREAT I

Information: One hundred-eighteen sources of information were reviewed that mentioned various aspects of channel maintenance and construction in the GREAT I Region. Approximately half of these were of a general nature, rather than addressing a specific type of activity (Table 37). The references relevant to specific aspects of channel maintenance and construction dealt primarily with dredging disposal, channel degradation, and water level fluctuations.

All pools in GREAT I were referred to in these studies, although some of the general articles included several pools (Table 37). Four studies, for example, which included the entire GREAT I Region, were of a general nature. Pool 8 was referenced most often (20 references) followed by Pools 5 (15 references) and 10 (11 references).

Voids: Although 118 references were made regarding various aspects of channel maintenance and construction, including all pools in the GREAT I Region, no references dealt specifically with training or closing structures, wing dams or straightening, and only one dealt specifically with revetments (Table 37).

Evaluation: Large-scale, broad spectrum evaluations of the environmental impacts of maintaining and operating the navigation system in the GREAT I Region were reported by the U.S. Army Corps of Engineers (1974) and Olson and Meyer (1976). Olson and Meyer (1976), however, concentrated on Pools 5

through 10 and provided a more comprehensive historical background. Studies of such magnitude are especially pertinent since many of the studies in the GREAT I Region are restricted to limited areas or specialized topics. Meanwhile, this portion of the Mississippi River is recognized as especially diverse and productive (Great River Environmental Action Team 1978).

The most apparent aspects of channel maintenance and construction are those of dredging and spoils disposal, and these topics have received much attention. Clafin (1977) and the Great River Environmental Action Team (1978) have reported on the effects of these activities, and Ziegler and Sohmer (1977) discussed plant community succession on disposal sites.

Recommendations: Studies should be designed to evaluate environmental effects of current training structures, particularly training and closing structures, wing dams, revetments and straightening techniques. Maintenance and construction activities and long-term effects should be considered in these studies. In addition, integrated studies should be performed to determine whether synergistic effects may occur; and standardized techniques should be adopted to make results comparable throughout the GREAT I Region and the Upper Mississippi River Basin.

Literature Cited:

Claflin, T. O. 1977. The effects of hydraulic dredging on the resuspension and transport of sediment material. In: A pilot study on effects of hydraulic dredging and disposal on water quality of the Upper Mississippi River (July 1976). GREAT I Water Quality Work Group.

Great River Environmental Action Team. 1978. GREAT I, interim status report. Great River Environmental Action Team (GREAT I). 105 pp. and Appendices.

Great River Environmental Action Team I. Water Quality Work Group. 1978. A pilot study on effects of hydraulic dredging and disposal on water quality of the Upper Mississippi River (July, 1976). Great River Environmental Action Team (GREAT I). various pagings.

Olson K. and M. Meyer. 1976. Vegetation, land and water surface changes in the upper navigable portion of the Mississippi River basin over the period 1929 to 1923. U.S. Army Corps of Eng. Phaze IV. Contr. No. DACW - 37-74 - C-0043. 19 pp. + App A-G.

U.S. Army Corps of Engineers. 1974. Draft Environmental Impact Statement: Operation and maintenance Upper Mississippi River, Head of navigation to Guttenberg, Iowa. U.S. Army Corps of Engineers. St. Paul, MN.

Ziegler, S. and S. Sohmer. 1977. The flora of dredged material sites in navigation pool 8 of the Upper Mississippi River. Technical Report D-77-31, Environmental Effects Laboratory. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 97 pp.

b. GREAT II

Information: A total of 83 sources of information were reviewed that mentioned various aspects of channel maintenance and construction in the GREAT II Region. Twenty-six of these were of a general nature, rather than dealing with a specific type of activity (Table 38). The references relevant to specific aspects of channel maintenance and construction, dealt primarily with dredging disposal, channel degredation, training structures and navigation dams.

All pools, except Pool 22, were referred to in these studies, though some articles, typically of a general nature, included several pools (Table 38). Many references (11) included the entire GREAT II Region. Of the separate pools, Pool 14 was referenced most often (13 references).

Voids: Although 83 references were made regarding various aspects of channel maintenance and construction in the GREAT II Region, reports included all pools except Pool 22, and no references dealt specifically with wing dams (Table 38). The effects of straightening, revetments and closing structures and water level fluctations were dealt with least freouently. The pools receiving fewest references were 22 and 18 with 0 and one reference, respectively.

Evaluation: In general, a wide variety of studies have been completed concerning most aspects of channel maintenance and construction within the GREAT II Region. Results of most of these studies have been incorporated into two comprehensive reports by the U.S. Army Corps of Engineers (1974a, 1974b). Also two studies compared habitat types and habitat conditions as well as habit changes from before and after construction, maintenance and operations

of the navigation channel in the GREAT II Region (McDonald and Konefes 1977, U.S. Army Corps of Engineers 1976).

In addition to these major reports, certain specific effects of channel maintenance and construction activities have been studied. Anding (1965) described investigations to improve techniques for stabilizing the bed and banks of the Mississippi River. Gale (1969, 1975) described benthos populations in Pool 19 prior to dredging operations, and the Iowa Institute of Hydraulic Research (1969) described the effects of navigation dam operations on river flows. The U.S. Army Corps of Engineers (1973 a,b) projected the value of levees and other navigation and flood control structures.

Recommendations: Additional studies should be performed to evaluate the impacts of channel maintenance and construction activities on fish and wildlife resources in the GREAT II Region. Pools requiring the greatest amount of attention are: 12, 17, 18, 21, and 22. Those aspects of channel maintenance and construction activities which should be particularly included are: closing structures, wing dams, revetments, straightening, and water level fluctuations. Whenever possible, studies should be standarized and integrated to include as many pools as possible and as many aspects of channel maintenance and construction as possible.

Literature Cited:

Anding, M. 1965. Hydraulic analysis of Mississippi River channel miles 373 to 603, fiscal year 1964. Potam. Invest. No. 19-1. U.S. Army Engr. Waterways Exp. Sta. Vicksburg, MS.

Gale, W. 1969. Bottom fauna of Pool 19, Mississippi River with emphasis on the life history of the fingernail clam, Shaerium transversum. Ph.D. Thesis. Iowa State University. Ames, IA. 241 pp.

__________. 1975. Bottom fauna of a segment of Pool 19 Mississippi River near Fort Madison, Iowa, USA. 1967-68. Iowa State J. Res. 49:357-372.

Iowa Institute of Hydraulic Research. 1969. Effects of navigation dam operating procedures on Mississippi River flood levels. U. S. Army Corps of Engr. Contr. No. DACW 23-69-C. 0024. 9 pp.

McDonald, D. and J. Konefes. 1977. Pre and post habitat conditions resulting from 9-ft. navigation channel, Upper Mississippi River, Pools 11-22. Univ. of Iowa, Inst. of Hydrol. Res.

U.S. Army Corps of Engineers. 1973a. Meredosia Levee and Drainage District, Illinois. Local Protection Project, Mississippi River. Draft environmental impact statement. Army Engineer District, Rock Island, IL. 21 pp.

________________. 1973b. Clinton, Iowa, Local Protection Project, Mississippi River. Draft environmental impact statement. Army Engineer District, Rock Island, IL. 20 pp.

________________. 1974a. Operation and maintenance, Upper Mississippi River, nine-foot navigation channel; final environmental impact statement, pool supplements, pools 11-22. Rock Island, IL. in 12 volumes.

________________. 1974b. Addendum to final environmental impact statement. Operations and maintenance, Upper Mississippi River nine-foot navigation channel, pools 11-22. Rock Island, IL. Various pagings.

________________. 1976. Quantitative and qualitative analysis of pre and post wildlife habitat conditions resulting from nine-foot navigation channel, Upper Mississippi River (Pools 11-22). Rock Island District. Rock Island, IL.

c. GREAT III

<u>Information</u>: A total of 68 references regarding various aspects of channel maintenance and construction in the GREAT III Region were reviewed. Twenty seven of these were of a general nature rather than of a specific type of activity (Table 39). Some references were for all portions of the Region or of the entire Region; however most (14 references) were for the Lower Stretch. The references relevant to specific aspects of channel maintenance and construction dealt primarily with water level fluctuations and channel degredation.

All portions of the GREAT III Region were referred to regarding various aspects of channel maintenance and construction with Pool 26 receiving the most references.

<u>*Voids*</u>*: Of the 68 references regarding channel maintenance* and construction in the GREAT III Region, in excess of 70% were concerned with general aspects or aspects of navigation dams, and relatively few references dealt with the other aspects (Table 39). No references concerning effects of wing dams were found, and only one reference each was found concerning water level fluctuations and revetments. Two references each were made concerning training structures and closing structures while three references each were made to dredging disposal and straightening. Only two references of a general nature were found for Pool 24 and only four of a general nature were found for Pool 25.

<u>Evaluation</u>: A great deal of effort has been expended in the GREAT III Region to obtain environmental surveys and to evaluate the effects of the navigation system on the river environment. The environmental

aspects of the operation and maintenance of the navigation system in GREAT III have been well studied. Emge (1972) presented a study plan for an inventory of environmental conditions associated with channel maintenance and construction, and Colbert et al. (1975 a,b) presented an environmental inventory and assessment of navigation in GREAT III with a discussion of impacts of the operation and maintenance on the aquatic system. Terpening et al. (1975) presented an environmental inventory of the floodplain areas. Solomon et al. (1975) also described a general environmental inventory of the GREAT III Region, but included comments on changes due to the navigation system.

Several references included comments about specific aspects of the operation, maintenance and construction of the navigation system. Johnson et al. (1974) studied the effects of contraction of the lower stretch on the river and on terrestrial and aquatic flora and fauna. Emge et al. (1974 a,b,c) performed a physical, chemical and biological inventory of side channel habitats and river border habitats. Sparks (1975) performed a fish survey and commented on the impacts of the navigation system, and Schram and Lewis (1974) and Ragland (1974) demonstrated importance of the side channel habitats. Johnson (1976) and Solomon et al. (1974) studied dredging and dredge disposal sites and described their effects on the physical, chemical and biological parameters.

Lock and Dam 26 in GREAT III is under consideration for replacement; consequently, a large number of references were available concerning this aspect of the operation and maintenance of the navigation system (Board of Engineers for Rivers and Harbors 1976; Illinois Department of Conservation 1977; Illinois Department of Transportation 1975; Peat, Marwick, Mitchell and Company 1975; Sverdrup and Parcel and Associates, Inc. 1976; U.S. Army Corps

of Engineers 1968). Oswalt and Pickering (1973) commented on a model of the Lock and Dam, and Harland, Bartholomew and Associates (1974) presented a plan for the environmental enhancement of the facility. The U.S. Army Corps of Engineers (1976 a,b) performed the environmental statement regarding the impact of the replacement of Lock and Dam 26.

Support for replacement of Lock and Dam 26 is not universal. The railroad industry opposes the replacement in fear that it would result in decreased railroad revenues (Garing and Harrison 1975), and this concern is supported by the U.S. Department of Transportation (1975). That agency also stated that there was no current requirement to improve the facility and that it would be adequate until 1990 (U.S. Department of Transportation 1977).

Recommendations: Environmental inventories in the GREAT III Region should be repeated periodically to evaluate whether changes occur due to channel maintenance and construction. In addition, specific studies should be designed to evaluate the impacts of channel maintenance and construction activities other than navigation dams and channel degradation. Where possible, studies should be designed to integrate the evaluation of more than one aspect. More studies should be performed in Pools 24 and 25.

Literature Cited:

Board of Engineers for Rivers and Harbor. 1976. Locks and Dam No. 26 (Replacement), Mississippi River, Alton, Illinois. 24 February 1976.

Colbert, B. K., J. E. Scott, H. Johnson and R. C. Solomon. 1975. Environmental inventory and assessment of navigation Pools 24, 25 and 26, Upper Mississippi and Lower Illinois Rivers. An aquatic analysis. Army Engineer Waterways Experiment Station, Vicksburg, MS. 368 pp.

__________. 1976. Environmental inventory and assessment of navigation Pools 24, 25 and 26, Upper Mississippi and Lower Illinois Rivers. An aquatic analysis. USACE Waterways Experiment Station, Vicksburg, MS. 368 pp.

Emge, W. P. 1972. Study plan for environmental inventory and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri, and Cairo, Illinois. USACE Waterways Experiment Station, Vicksburg, MS. 36 pp.

Emge, W. P., R. C. Solomon, J. H. Johnson, C. R. Bingham, and B. K. Colbert. 1974a. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River Army Engineer Waterways Experiment Station, Vicksburg, MS. 166 pp.

__________. 1974b. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River Army Engineer Waterways Experiment Station Vicksburg, MS. 595 pp.

__________. 1974c. Physical, biological, and chemical inventory of twenty-three side channels and four river border areas, Middle Mississippi River Army Engineer Waterways Experiment Station. Vicksburg, MS. 621 pp.

Foster, J. 1977. Flowline study, Mississippi and Illinois Rivers. Hydraulic model investigation. Army Engineer Waterways Experiment Station. Vicksburg, MS. 67 pp.

Garing J. D., and C. Harrison. 1975. Railroads join environmental groups to fight plans for new river locks near Alton, Illinois. Wall Street J. 40 pp.

Harland, Bartholomew and Associates. 1974. Lock and Dam No. 26 (Replacement) Upper Mississippi River Basin. Mississippi River - Alton, Ill. Environmental Study. Prepared for U.S. Army Corps of Engineers, St. Louis District. Design Memorandum No. 8 Architectural Treatment and Site Development.

Illinois Department of Conservation. 1977. Replacement of Alton Locks and Dam 26: An interim report of the DOT to the Subcommittee on water resources of the Senate Public Works Committee. March.

Illinois Department of Transportation. 1975. The replacement of Alton Locks and Dam 26: An advisory report of the DOT to the Senate Commerce Committee. September.

Johnson, J. H. 1976. Feasibility of using historic disposal areas, Upper Mississippi River, to evaluate effects of dredged material disposal on community structure of benthic organisms. Army Engineering Waterways Experiment Station, Vicksburg, MS. 90 pp.

Johnson, J. H., R. C. Solomon, C. R. Bingham, B. K. Colbert and W. P. Emge. 1974. Environmental analysis and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri, and Cairo, Illinois. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 148 pp.

Oswalt, N. R. and G. A. Pickering. 1973. Spillway for Lock and Dam 26, Mississippi River, Missouri and Illinois. Hydraulic Model Investigation. Vicksburg, MS. 65 p.

Peat, Marwick, Mitchell and Co. 1975. Evaluation of operational improvements at Locks and Dam 26, Mississippi River. July 1975.

Ragland, D. 1974. Evaluation of three side channels and the main channel border of the Middle Mississippi River as fish habitat. Springfield, VA. Prep. for U.S. Army Eng. Waterways Experiment Station AD - 786-142.

Schramm, H. and W. Lewis. 1974. Study of the importance of backwater chutes to a riverine fishery. Southern Illinois Univ., Carbondale. Fisheries Research Lab. Army Engineer Waterways Experiment Station. Vicksburg, MS. 153 pp.

Solomon, R. C., J. H. Johnson, C. R. Bingham and B. K. Colbert. 1974. Physical, biological, and chemical inventory and analysis of selected dredged and disposal sites, Middle Mississippi River. Army Engineer Waterways Experiment Station, Vicksburg, MS. Army Engineer District, St. Louis, MO. 207 pp.

Solomon, R. C., D. R. Parsons, D. A. Wright, B. K. Colbert and C. Ferris. 1975. Environmental inventory assessment of navigation pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers. Summmary Report. Army Engineer Waterways Experiment Station, Vicksburg, MS. 100 pp.

Sparks, R. 1975. Environmental inventory and assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers. An electro-fishing survey of the Illinois River. Illinois Natural History Survey. Havana River Research Lab. Army Engineer Waterways Experiment Station. Vicksburg, MS. 124 pp.

Sverdrup and Parcel and Associates, Inc. 1976. Locks and Dam 26 rehabilitation study. Prep for Nat. Comm. on Locks and Dam 26. June 1976.

Terpening, V., J. Nawrot, J. Sweet, and D. Damrau. 1975. Environmental inventory and assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers; Floodplain animals and their habitats. Southern Illinois Univ., Carbondale Cooperative Wildlife Research Lab. Army Engineers Waterways Experiment Station. Vicksburg, MS. 285 pp.

U.S. Army Corps of Engineers. 1968. Report on replacement Lock and Dam No. 26 Mississippi River, Alton, Main report. St. Louis Dist. (June).

________________. 1976a. Revised draft supplement environmental statement. Vol. I Lock and Dam No. 26 (Replacement) Upper Mississippi River Basin, Mississippi River - Alton, IL.

________________. 1976b. Final environmental statement, Locks and Dam No. 26, Mississippi River, Alton, Illinois. Vols. 1 and II. Office of the Chief of Engineers, Wash. D.C. 20314.

U.S. Department of Transportation. 1975. Report: The replacement of Alton Locks and Dam 26. An advisory rept. to the Senate Commerce Com. September.

________________. 1977. The replacement of Alton Locks and Dam (Single 1200' Lock Proposal). Interim report to subcommittee on water resources of the Senate Public Works Committee. 46 pp.

d. Upper Mississippi River

Information: A total of 65 references regarding various aspects of channel maintenance and construction in the Upper Mississippi River not specific to any GREAT Region were reviewed, and of these 31 were of a general nature (Table 39). Eleven dealt with channel degradation; seven dealt with dredging disposal; four dealt with water level fluctuations and navigation dams; and three dealt with straightening.

Voids: Of the 65 references relevant to various aspects of channel maintenance and construction in the Upper Mississippi River, only one each concerned training structures, closing structures, and revetments (Table 39). Two references addressed closing structures.

Evaluation: General references dealing with channel maintenance and construction activities in the Upper Mississippi River included a variety and combination of topics. The U.S. Army Corps of Engineers (1978) summarized information on fish and wildlife habitat changes resulting from construction, maintenance, and operation of the Upper Mississippi River navigation system; and Zimmerman and Knight (1978) assembled a bibliography of the effects of navigation in inland waterways on the environment and certain aspects of the relationships.

Other references dealt with more specific topics. Brady (1976) and McMahon (1975) discussed adverse effects, as well as some positive effects of dredge disposal, while Fernholz (1977) discussed dredge disposal site selection. Ellis (1978) and Kelley (1949) evaluated fish communities and changes associated with habitats created as a result of the navigation system.

Fremling et al. (1976) documented degradation and habitat loss in backwater areas and recommended rehabilitation measures. Fremling and McConville (1976) discussed the feasibility and environmental effects of opening side channels. Christenson (1957) and Greenbank (1946) reported on the effects of seasonal navigation pool drawdowns.

Finally, the Upper Mississippi Comprehensive Basin Study (1970) analyzed the needs of current and future waterborne commerce on the Upper Mississippi River. Waelti (1974) commented that if dredging for navigation channel maintenance in the Upper Mississippi River were discontinued, barge traffic would decline, and this would lead to economic collapse of the region. Nonetheless, environmentalists typically oppose increases in channel maintenance and construction activities because of the impact on fish and wildlife habitat (Cullimore 1971, Ela 1974).

Recommendations: See Recommendations discussed in a. GREAT I, b. GREAT II and c. GREAT III.

Literature Cited:

Brady, J. 1976. Environmental implications of dredged material disposal on the Upper Mississippi River. Presented at World Dredging Conf. on Env. Effects and Technology of Dredging. San Francisco, July 10-12, 1976, 321 pp. (16).

Christenson, L. M. 1957. Some characteristics of the fish population in backwater areas of the Upper Mississippi River. M. S. Thesis, Univ. of Minn. St. Paul, MN. 125 pp.

Cullimore, D. 1921. Corps vs. conservationists, battle for Upper Mississippi. Izaak Walton Mag. (2). p. 8.

Ela, J. 1974. Corps games in Mid-America. Sierra Club B, 59 (9): 11-15.

Ellis, J. M. 1978. Fish communities in three successional stages of side channels of the Upper Mississippi River. M.S. Thesis. Univ. Missouri. 66 pp.

Fernholz, W. 1977. Nine-foot channel maintenance surveillance, Wis. Dept. Nat. Res. Fish Div. 1975-76. Sum. Rept. No. 12. 17 pp.

Fremling, C. and D. McConville. 1976. The feasibility and environmental effects of opening side channels in three areas of the Upper Mississippi River (West Newton Chute, Fountain City Bay, and Sam Gordy's Slough). Quart. Prog. Rept. USFWS Contr. No. 14-16-088-949.

Fremling, C. R., D. N. Nielsen, D. R. McConville and R. N. Vose. 1976. Aquatic Plants In: The Weaver Bottoms: a field model for the rehabilitation of backwater areas of the Upper Mississippi River by modification of standard channel maintenance practices. Final report to the U.S. Army Corps of Engineers, St. Paul District. Contracts DACW37-75-C-0193 and DACW37-75-C-0194. 52 pp.

Green, W. 1960. Ecological changes on the Upper Mississippi Wildlife and Fish Refuge since inception of the 9-foot channel. U.S. D.I. Bur. Sport Fish. and Wild. Winona, MN. 15 pp.

Greenbank, J. 1946. Effects of midwinter drawdowns of the Upper Mississippi River on aquatic wildlife. UMRCC Invest. Rept. No. 5. 10 pp.

Kelley, D. 1949. Suggested effects of the proposed twelve foot channel on fish life in the Upper Mississippi River. UMRCC Invest. Rept. No. 35. 7 pp.

McMahon, G. 1975. The impacts of dredge spoil placement on the Upper Mississippi River. Final Report Nat. Sci. Foundation.

Upper Mississippi River Comprehensive Basin Study. 1970. Volume V. Appendix I: Flood Control. Appendix J: Navigation Committee, Chicago, IL. 369 pp.

U.S. Army Corps of Engineers, Army Engineer Division, North Central. 1978. Summary report of fish and wildlife habitat changes resulting from the construction of a Nine-Foot Channel in the Upper Mississippi River, Minnesota River, St. Croix River and Illinois Waterway. Chicago,IL. Various pagings.

Waelti, J. J. 1974. Flood control, navigation, and other alternative water resources policies in Minnesota. Minnesota Univ. Minneapolis. Water Resources Research Center. Office of Water Resources Research, Washington, D.C. 27 pp.

Zimmerman, B. P. and D. E. Knight. 1978. Effects of navigation in inland waterways on the environment related water quality parameters; an annotated bibliography. ERT/ Ecology Consultants, Inc. Fort Collins, CO. 152 pp.

e. Non-Upper Mississippi River

Information: A total of 188 references were reviewed regarding various aspects of channel maintenance and construction in areas outside the Upper Mississippi River (Table 39). Sixty-nine of these were considered to be of a general nature. Aside from these, most references dealt with dredging disposal, channel degredation, and navigation dams.

Voids: Of the 188 references dealing with various aspects of channel maintenance and construction in areas outside the Upper Mississippi River, no references dealt with closing structures or wing dams.

Evaluation: Navigation channel maintenance and construction is an important activity in many areas outside the Upper Mississippi River. Many references are reports of particular projects which include a variety of activities, general or specific comments about navigation channel maintenance or construction or present an overview of the activities. Overview studies of environmental impacts of navigation channel maintenance activities have been conducted. Morris et al. (1968) studied the effects of mainstem impoundments and channelization on limnological parameters, and Darnell et al. (1976) evaluated the environmental impacts of construction and channel improvement activities on wetlands in the United States; the primary effect they reported was direct habitat loss.

Many references pertained to navigation locks and dams; however, most were discussions of specific project design and included few specific comments about impacts. Arnold (1973) pointed out that improvement of navigation locks and dams resulted in a boom in river shipping because of the east of moving bulky cargo. The result was economically beneficial.

Dredging is a particularly important topic. Smith (1977) assembled information on environmental and ecological effects of dredging and dredge spoil. Markey and Putnam (1976) studied the effects of maintenance dredging on selected ecological parameters in Gulfport, Mississippi and found no significant or long range effects; however, Forsage and Carter (1974) found that gravel dredging in the Brazos River, Texas caused major changes in the fish and benthic macroinvertebrates.

Recommendations: Studies from the downstream reaches of the Mississippi River may be of value in answering questions or solving problems encountered in the Upper Mississippi River Basin. It is suggested that as questions or problems are identified, a carefully designed and specifically oriented literature search would be valuable. Additional information regarding the impacts of closing structures, wing dams, revetments, straightening, and water level fluctuations on fish and wildlife resources may be especially useful.

Literature Cited:

Arnold, B. 1973. Barge traffic crowds inland waters as the business booms. Wall Street J. April 13, 1973. pp.1

Darnell, R. M., W. E. Pequegnat, B. M. James, F. J.Benson, and R. A. Defenbaugh. 1976. Impacts of construction activities in wetlands of the United States. Teneco Corporation, College Station, TX. 426 pp. EPA/600/3-76/045.

Engler, R. M., and R. T. Saucier. 1977-current. Movement of dredged material. Army Engineer Waterways Experiment Station. Vicksburg, MS.

Forsage, A., and N. Carter. 1974. Effects of gravel dredging on the Brazos River. In: Proc. 27th Ann. Conf. Southeastern Assoc. of Game and Fish Commissions, Hot Springs, Arkansas. 1-17 October, 1973: 69-709. Texas Parks and Wildlife Dept. Fort Worth.

Markey, J. and H. Putnam. 1976. Study of the effects of maintenance dredging on selected ecological parameters in the Gulfport ship channel, Gulfport, Mississippi. In: Proceedings of the special conference on dredging and its environmental effects. Mobile, Alabama. January 26-28, 1976; 821-822. Amer. Soc. Civil Engineers. New York.

Morris, L., R. Langmier, and T. Russell. 1968. Effects of main stem impoundments and channelization upon the limology of the Missouri River. Trans. Amer. Fish. Soc. 97(4):380-397.

Smith, M. 1977. Environmental and ecological effects of dredging; a report for 1963-1976. National Technical Information Service. Springfield, VA. 214 pp.

Thomas, B., and D. Watt. 1913. The improvement of rivers; a treatise on the methods employed for improving streams for open navigation by locks and dams. Second edition. J. Wiley and Sons. New York. In 2 volumes.

2. Harbors

a. GREAT I

For the discussion of maintenace and construction of harbors, all three GREAT Regions and Non Upper Mississippi River information have been combined.

Information: Twenty-five references were reviewed regarding various aspects of harbor maintenance and construction (Tables 40-42). The pool referred to in most of these references was Pool 19. Thirteen of the references discussed information from areas outside the Upper Mississippi River.

Voids: Most pools of the Upper Mississippi River had no information concerning harbor maintenance and construction specific to that pool. Except for Pool 19 and the Lower Stretch, all the information was of a general nature rather than discussing the specific aspects of dredging, dredge disposal, turbidity, or toxic material.

Evaluation: Both references dealing with harbor maintenance and construction in the GREAT I Region were environmental impact statements concerning further development of existing facilities. One facility was a small boat harbor in Pool 4 (U.S. Army Corps of Engineers 1971b) while the other was a coal terminal in St. Paul, Minnesota (U.S. Army Corps of Engineers 1973). Both reports indicated that the environmental impact would be minimal and the projects would be beneficial. General and certain specific aspects of the environmental impacts of harbor maintenance, construction and operation were discussed in the U.S. Army Corps of Engineers (1974) comprehensive study of the operation and maintenance of the navigation system in the GREAT II Region. Specific comments regarding the impacts of construction and maintenance of the Fort Madison Commerical Harbor were included in the U.S. Army Corps of Engineers

AD-A096 480 HAZLETON ENVIRONMENTAL SCIENCES CORP NORTHBROOK IL F/G 6/6
GREAT RIVER ENVIRONMENTAL ACTION TEAM (GREAT II). LITERATURE RE--ETC(U)
DEC 80 DACW25-79-C-0066
UNCLASSIFIED ES-9057 NL

AD A 096480

(1971a) Environmental Impact Statement regarding the project. They reported that turbidity would be temporarily increased during construction and maintenance dredging and that there would be some loss of fish and wildlife habitat as well as scenic and aesthetic values as a result of canalization and spoiling within the designated areas. The Izaak Walton League went on record as opposing this project since they objected to the loss of fish and wildlife habitats in the Keokuk Pool (Anonymous 1972).

Tuttle (1970) discussed sediment problems in the St. Louis harbor, and Franco (1972) described a study on a model of the St. Louis harbor to determine the cause of shoaling and to develop a plan to eliminate the problem.

Most references regarding harbor maintenance and construction activities outside the Upper Mississippi River were superficial in nature; however, O'Neal and Sceva (1971) studied the effects of dredging on water quality and included comments on dredging equipment, dredge spoil disposal, and sediment characteristics in northwest harbors. Water and Air Research, Inc. (1975) monitored the effects of maintenance dredging in Gulfport Harbor, Mississippi and found no significant or lasting effects. The U.S. Comptroller General (1977), however, indicated that more information was needed regarding environmental and economic matters related to harbor dredging and dredging material disposal.

Recommendations: Localized studies should be performed to obtain baseline reference information if further harbor construction and maintenance activities are planned in the Upper Mississippi River. Studies should be performed to assess the environmental impact of ongoing harbor construction

and maintenance activities. In addition, it may be valuable to survey the status of the environment near the sites of completed harbor maintenance and construction activities to predict the duration of any environmental impact. Studies outside the Upper Mississippi River basin may be of value in answering questions or solving problems encountered within the Upper Basin. It is suggested that as questions or problems are identified, a carefully designed and specifically oriented literature search would be valuable. Additional information regarding the impacts of essentially all aspects of harbor maintenance and construction activities would be useful.

Literature Cited:

Anonymous. 1972. Walton League opposes dredge and fill projects on Upper Mississippi River. Outdoor America 37 (1):9.

Franco, J. 1972. Shoaling conditions, St. Louis Harbor, Mississippi River. Army Engineers Waterways Exp. Station, Vicksburg, MS. 56 pp.

O'Neal, G., and J. Sceva. 1971. The effects of dredging on water quality in the Northwest. Environmental Protection Agency, Office of Water Programs, Region X. Seattle, WA. 163 pp.

Tuttle, J. 1970. Sediment problems in St. Louis Harbor. Proc. Sem. on Sed. Transp. in Rivers and Reservoirs. Pap. No. 7, Corps of Eng. Hydrul. Eng. Cen., Davis, CA.

U.S. Army Corps of Engineers. 1971a. Navigation Project, Mississippi River, Fort Madison, Iowa. Commercial boat harbor, Fort Madison Iowa. Final environmental impact statement: Army Engineer District, Rock Island, IL. 27 pp.

______________. 1971b. Small-boat harbor, Mississippi River at Pepin, Wisconsin. Final environmental impact statement. Army Engineer District, St. Paul, MN. 34 pp.

______________. 1973. Pig's Eye Coal Terminal, Mississippi River at St. Paul, Ramsey County, Minnesota. Draft environmental impact statement Army Engineer District, St. Paul, MN. 220 pp.

______________. 1974. Final Environmental Impact Statement, Pools 11 thru 22, operations and maintenance, Upper Mississippi River, 9-Foot navigation channel. U.S. Army Corps of Engineers, Rock Island, IL.

U.S. Comptroller General. 1977. Report to Congress: Dredging America's waterways and harbors -- more information needed on environmental and economic issues. U.S. Government Printing Office, Washington, D.C. 64 pp.

Water and Air Research, Inc. 1975. A study on the effects of maintenance dredging on selected ecological parameters in Gulfport Harbor, Mississippi. Gainesville, FL. 392 pp.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

3. Bridges and Pipelines

a GREAT I

For this topic, all three GREAT Regions plus non Upper Mississippi River information will be discussed together.

Information: None

Voids: No references were available that addressed bridge and pipeline maintenance activities from any of the three GREAT Regions, nor from any non Upper Mississippi River locations (Tables 43-45).

Evaluation: None

Recommendations: Localized studies should be performed to obtain baseline reference information if future bridge and pipeline construction and maintenance activities are planned in the GREAT I, II and III Regions. Studies should also be performed to assess the environmental impact of ongoing bridge and pipeline construction and maintenance activities. In addition, it may be valuable to conduct surveys in the vicinity of bridge and pipeline maintenance and construction activities of various ages to predict the duration of any environmental impact.

In addition, carefully designed literature surveys should be performed to obtain background information regarding bridge and pipeline construction and maintenance activities in areas outside the Upper Mississippi River.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

B. Encroachment, Including Flood Protection

1. Industrial

a. GREAT I

For this topic all three GREAT Regions and non Upper Mississippi River information will be discussed together.

Information: Thirty-one references regarding industrial enroachment activities were reviewed in the Upper Mississippi River (Tables 46-48), In addition to this, one reference was available from a non Upper Mississippi area.

Voids: No reference regarding industrial encroachment activities were available which were specific to Pools 2, 4, 5A, 7, 8, 20-26.

Evaluation: In general, there are few detailed studies describing the effects of encroachment for industrial purposes. Typically, the available references deal with some small aspect in a restricted area. Fremling, et al. (1973), however, include a more detailed description of the impacts of industrial development on Pool 5.

Encroachment activities and flood protection works for industrial purposes which were associated with the operation of the navigation system in the GREAT II Region were discussed in the U.S. Army Corps of Engineers (1974a) comprehensive Environmental Impact Statement. The impact of various projects which include flood control for industrial development were discussed in several U.S. Army Corps of Engineers Environmental Impact Statements. These include the Clinton, Iowa, Local Protection Projects which provide drainage facilities and flood protection against flooding and substantial benefits for residential, commercial and industrial development (U.S. Army Corps of Engineers, 1973b). The Fort Madison Commercial Harbor Project was predicted to result in

some loss of fish and wildlife habitat, but also provide an opportunity for abundant industrial benefits (U.S. Army Corps of Engineers 1971). Similarly, at Clinton, Iowa, Muscatine, Iowa, and Rock Island, Illinois, although some adverse impacts on fish and wildlife habitat were expected, the net results of the flood protection projects may benefit the fish and wildlife, and also greatly aid industrial developments (U.S. Army Corps of Engineers, 1974b, 1975 and undated).

Recommendations: Studies should be conducted to evaluate the environmental impacts of industrial enroachment activities in the Upper Mississippi River. The studies should be designed, if possible, to separately assess the impacts from flood protection works from those of strictly industrial activities. Standarized techniques should be applied throughout the Upper Mississippi River.

In addition a carefully designed literature survey to obtain information dealing with industrial encroachment outside the Upper Mississippi River would be of value in interpreting data from within the Upper Mississippi River.

Literature Cited:

Fremling, C., D. Gray, and D. Nielsen. 1973. Phase III. Pool 5, northern section of Upper Mississippi River Valley. Winona State College, Winona, MN. 298 pp.

U.S. Army Corps of Engineers. 1971. Navigation Project, Mississippi River, Fort Madison, Iowa. Commercial boat harbor, Fort Madison, Iowa. Final environmental impact statement. Army Engineer District, Rock Island, IL 27 pp.

______________. 1973. Clinton, Iowa. Local protection project. Mississippi River. Draft environmental impact statement. Army Engineer District, Rock Island, IL 20 pp.

______________. 1974a. Final Environmental Impact Statement, Pools 11 thru 22, operations and maintenance, Upper Mississippi River, 9-foot navigation channel. U.S. Army Corps of Engineers, Rock Island, IL.

______________. 1974b. Final Environmental Statement, Clinton, Iowa, local protection project. U.S. Army Corps of Engineers, Rock Island, IL.

______________. 1975. Revised Draft Environmental Statement, Muscatine Island Levee District and Muscatine-Louisa County Drainage District No. 13, Iowa, Local Flood Protection. Office of the Chief of Engineers, Dept. of Army, Wash. D.C.

______________. Undated. Final Environmental Statement, Rock Island, Ill. Mississippi River, Local Flood protection Project. U.S. Army Corps of Engineers, Rock Island, IL.

b. GREAT II

See a. GREAT I.

c. GREAT II

See a. GREAT I.

2. Municipal

a. GREAT I

For this topic, all three GREAT Regions and the non Upper Mississippi River information have been combined.

Information: Fourteen references regarding aspects of encroachment activities for municipal developments from the Upper Mississippi River were reviewed (Tables 46-48). Of these, one was from a non Upper Mississippi River area.

Voids: No references were made regarding municipal encroachment activities for Pools 2, 4, 5, 5A, 7, 8, 9, 11, 13, 15, and 18-26.

Evaluation: Most references regarding encroachments for municipal developments dealt with some aspect of local importance (Bollant 1974, Krosch 1969). The project proposed by the U.S. Army Corps of Engineers (1971), however is substantial. It discussed evacuation and management of the floodplain at Prairie du Chien, Wisconsin requiring the relocation of a number of families. References discussing specific impacts of encroachment activities related to municipal developments dealt largely with flood protection projects and were limited primarily to Environmental Impact Statements. Flood protection works at Clinton, and Muscatine, Iowa and Rock Island, Illinois, are expected to have limited and mostly temporary environmental impacts, but will result in substantial economic, psychological and social gains for the municipalities (U.S. Army Corps of Engineers 1973, 1974a,b, and Undated).

Recommendations: Studies should be conducted to evaluate the environmental impacts of municipal enroachment activities for the Upper Mississippi River. The studies should be designed to separately assess the impacts from flood protection works from other strictly municipal activities. Standardized techniques should be applied throughout the river.

In addition, a carefully designed literature survey to obtain information regarding encroachment and flood protection works for municipal purposes in areas outside the Upper Mississippi River would be of value in interpreting data from within the Upper Mississippi River.

Literature Cited:

Bollant, R. 1974. Dredging harmful, Winona disproves it. Public Works Magazine. 104(3):72.

Krosch, H. 1969. Winter water temperatures and ice cover on Lake St. Croix in the vicinity of the Allen S. King Power Plant. Minn. Dept. of Nat. Res. Spec. Publ. No. 77.

U.S. Army Corps of Engineers. 1971. Wisconsin. Mississippi River at Prairie du Chien. Evacuation and management of the flood plain of record at Prairie du Chien, located on the Mississippi River in Crawford County. Office of the Chief of Engineers. Washington, D.C. 23 pp.

______________. 1973. Clinton, Iowa. Local protection project. Mississippi River. Draft environmental impact statement. Army Engineer District, Rock Island, IL. 20 pp.

______________. 1974a. Draft Environmental Statement, Davenport, Iowa local flood protection project, Mississippi River, Davenport, Iowa. U.S. Army Corp of Engineers, Rock Island, IL.

______________. 1974b. Final Environmental Statement, Clinton, Iowa, local protection project. U.S. Army Corps of Engineers, Rock Island, IL.

______________. 1975. Revised Draft Environmental Statement, Muscatine Island Levee District and Muscatine-Louisa County Drainage District No. 13, Iowa, local flood protection. Office of the Chief of Engineers, Dept. of Army, Wash. D.C.

______________. Undated. Final Environmental Statement, Rock Island, Illinois, Mississippi River, local flood protection Project. U.S. Army Corps of Engineers, Rock Island, IL.

b. GREAT II

See a. GREAT I.

c. GREAT II

See a. GREAT I.

3. Agricultural

a. GREAT I

For this topic, all three GREAT Regions and non Upper Mississippi River information have been discussed together.

Information: Only seven references were made regarding encroachment activities for agricultural purposes from the Upper Mississippi River (Tables 46-48). In addition to this, one reference was available from outside the Mississippi River.

Voids: No references were made regarding encroachment activities for agricultural purposes specific to Pools 1-13, 15, and 18-26.

Evaluation: References dealing with encroachment activities for agricultural purposes are limited to several U.S. Army Corps of Engineers Environmental Impact Statements for proposed projects. The project for the Meredosia Levee and Drainage District in Illinois, for example, is substantial (U.S. Army Corps of Engineers 1973). It would protect 10,400 acres of farmland and 85 farmsteads. The project at Muscatine, Iowa, to provide flood protection and increase surface drainage, would affect 4100 acres including agricultural areas (U.S. Army Corps of Engineers 1975), and another project would provide a limited amount of floodplain protection in the vicinity of Davenport, Iowa (U.S. Army Corps of Engineers 1974).

Recommendations: Studies should be conducted to evaluate the environmental impacts of encroachment activities for agricultural purposes from the Upper Mississippi River. The studies should be designed, if possible, to separately assess the impacts of flood protection works from those of strictly agricultural purposes. Standarized techniques should be applied throughout the region.

Literature Cited:

U.S. Army Corps of Engineers. 1973. Meredosia Levee and Drainage District, Illinois. Local protection project, Mississippi River. Draft environmental impact statement. Army Engineer District, Rock Island, IL. 21 pp.

______________. 1974. Draft Environmental Statement, Davenport Local Flood Protection Project, Mississippi River, Davenport, Iowa. U.S. Army Corps of Engineers, Rock Island, IL.

______________. 1975. Revised Draft Environmental Statement, Muscatine Island Levee District and Muscatine-Louisa County Drainage District No. 13, Iowa, Local Flood Protection. Office of the Chief of Engineers, Dept. of Army, Wash. D.C.

4. Recreational

a. GREAT I

<u>Information</u>: Twenty-two references were reviewed regarding encroachment activities for recreational developments in GREAT I Region (Table 46). Pools 5, 7, and 10 were referenced most often.

<u>Voids</u>: Of the 22 references made regarding encroachment activities for recreational development in GREAT I Region, none were specific to Pool 2 (Table 46). No references dealt with flood protection activities.

<u>Evaluation</u>: The upper portion of the Mississippi River, including GREAT I, is an important source of recreation for the inhabitants of the area and much of the river is set aside as a wildlife refuge (U.S. Department of the Interior 1964). In addition, recreational use is monitored and new recreational developments are planned and added to provide more recreational opportunities (U.S. Army corps of Engineers 1971, Wright 1970). Nonetheless, there is a continued interaction between the operation of the commercial navigation and recreational interests (Fremling et al. 1973), and Fremling (1977) has predicted that future construction and expansion activities will have a substantial impact on recreational facilities and opportunities.

<u>Recommendations</u>: Additional studies should be conducted to evaluate the environmental impacts of encroachment activities for recreational purposes in the GREAT I Region. The studies should be designed, if possible, to separately assess the impacts from flood protection works from those of strictly recreational purposes. Standardized techniques should be applied throughout the region.

Literature Cited:

Fremling, C. 1977. Mississippi River - 1999. A paper presented at the annual meeting of Upper Mississippi River Research Consortium. June 10, 1977. Winona St. University. 5 pp.

Fremling, C., D. Gray, and D. Nielsen. 1973. Phase III. Pool 5 northern section of Upper Mississippi River Valley. Winona State College. Winona, MN. 298 pp.

U.S. Army Corps of Engineers. 1971. Wisconsin. Mississippi River at Prairie du Chien. Evacuation and management of the flood plain of record at Prairie du Chien, located on the Mississippi River in Crawford County. Office of the Chief of Engineers. Washington, D.C. 23 pp.

U.S. Department of the Interior. 1964. Upper Mississippi River Wildlife and Fish Refuge. U.S. Department of the Interior. Fish and Wildlife Service. Refuge Leaflet 90-A.

Wright, K. 1970. Concentrations of fishermen on the Mississippi River as determined by aerial angler counts between 1963 and 1965 with comparisons to prior counts. Wis. Dept. Nat. Res., Div. Fish, Game and Enforcement. Bur. Fish Manage. Manage. Rept. No. 29. 5 pp.

b. GREAT II

Information: Twenty-eight references were reviewed regarding encroachment activities for recreational purposes in the GREAT II Region (Table 47). Pool 14 was referenced most often. Two references for Pool 14 dealt with flood protection activities.

Voids: Of the 28 references made regarding encroachment activities for industrial purposes in the GREAT II Region, none were specific to Pool 22 (Table 47).

Evaluation: In addition to providing an economic asset to the Midwest, the Mississippi River provides abundant recreational opportunities (U.S. Army Corps of Engineers 1974a). Much of the recreational value is intrinsic, but a great deal is directly or indirectly the result of the navigation system (Corps of Engineers 1974, 1977; Harker 1978). Typically, public recreation values increase as a result of projects intended for municipal, agricultural or industrial developments (U.S. Army Corps of Engineers 1973, 1974b); however, occasionally, recreational values may decline as a result of a particular project (U.S. Army Corps of Engineers 1971). Utilization and development of existing opportunities for recreation in the GREAT II Region is based on various surveys and reviews (Wright 1970, U.S. Department of Conservation 1958a), and planning for future developments to improve recreational opportunities is continuous (Wright 1970, U.S. Department of the Interior 1948, Illinois Department of Conservation 1958b).

Recommendations: See Recommendations for a. GREAT I.

Literature Cited:

Harker, G. R. 1978. GREAT II (Great River Environmental Action Team), Recreation Work Group - Literature Review. Western Illinois University. Macomb, IL.

Illinois Department of Conservation. 1958a. Review of proposed access areas for the Mississippi River.

______________. 1958b. General plan and cooperative lands Mississippi River.

U.S. Army Corps of Engineers. 1971. Navigation Project, Mississippi River, Fort Madison, Iowa. Commercial Boat Harbor, Fort Madison, Iowa. Final environmental impact statement. Army Engineer District, Rock Island, IL. 27 pp.

______________. 1973. Clinton, Iowa. Local Protection Project. Mississippi River. Draft environmental impact statement. Army Engineer District, Rock Island, IL. 20 pp.

______________. 1974a. Final Environmental Impact Statement, Pools 11 thru 22, Operations and Maintenance, Upper Mississippi River, 9-foot Navigation Channel. U.S. Army Corps of Engineers, Rock Island, IL.

______________. 1974b. Final Environmental Statement, Clinton, Iowa, Local Protection Project. U.S. Army Corps of Engineers, Rock Island, IL.

______________. 1977a. Environmental Harmony on the Mississippi River. Vol. I. Rock Island District. Information Brochure. 4 pp.

U.S. Department of the Interior. 1948. A preliminary report on fish and wildlife resources in relation to the Rock Island District Master Recreation Plan, Mississippi River, Wisconsin, Iowa, Missouri, Illinois. 8 pp.

______________. 1964. Upper Mississippi River Wildlife and Fish Refuge. U.S. Department of the Interior, Fish and Wildlife Service. Refuge Leaflet 90-A.

Wright, K. 1970. Concentrations of fishermen on the Mississippi River as determined by aerial angler counts between 1963 and 1965 with comparisons to prior counts. Wis. Dept. Nat. Res., Div. Fish, Game, and Enforcement, Bur. Fish Manage. Manage Rept. No. 29. 5 pp.

c. GREAT III

Information: Four references were made regarding encroachment activities for recreational developments in GREAT III Region, and seven were reviewed for the Upper Missislsippi River not specific to any GREAT Region (Table 48).

Voids: Of the four references made regarding encroachment activities for recreational development in the GREAT III Region, none pertained to Pools 24 or 25 or the Lower Stretch (Table 48). No references dealt with flood protection activities.

Evaluation: The U.S. Department of the Interior (1968) commented on the importance of the Upper Mississippi River Wildlife Refuge and projected that recreational needs of the area would increase; and Hella (1960) described a parkway for the Mississippi River in Minnesota. The Upper Mississippi River Comprehensive Basin Study (1970) discussed the water resources and the affects on recreational aspects of life, and the U.S. Congress House Committee on Internal Insular Affairs (1972) included statements on the Upper Mississippi River National Recreation Area.

Recommendations: See Recommendations for a. GREAT I.

Literature Cited:

Hella, U. 1960. A parkway for the mighty Mississippi. Minnesota Cons Volunteer March-April, 1960.

U.S. Congress. House. Committee on Internal Insular Affairs. 1972. Upper Mississippi River Wildlife and Fish Refuge. Bureau of Sport Fisheries and Wildlife.

U.S. Department of the Interior. 1968. Upper Mississippi River Wildlife and Fish Refuge. Bureau of Sport Fisheries and Wildlife.

Upper Mississippi River Comprehensive Basin Study. 1970. Volume VI. Appendix K: Recreation. Appendix L: Fish and Wildlife. Appendix M: Power. Appendix N: Agriculture. Coordinating Committee, Chicago, Ill. 555 pp.

d. Non Upper Mississippi River

Information: None

Voids: No references were made regarding encroachment activities for recreational purposes outside the Upper Mississippi River area (Table 48).

Evaluation: None

Recommendations: A carefully designed literature survey to obtain information regarding encroachment and flood protection works for recreational purposes in areas outside the Upper Mississippi River would be a valuable aid in interpreting data from within the Upper Mississippi River.

5. General

a. GREAT I

Information: In addition to the references categorized according to particular types of encroachment activities in the GREAT I Region, 30 references were made which could not be categorized into a particular type of activity (Table 46). At least one reference was made for each pool, but most references (4) were for Pool 6. Three references included the entire GREAT I Region. One reference for Pool 1 was concerned with flood protection works.

Voids: Of the 30 references to general aspects of encroachment activities in GREAT I Region, only two dealt with flood protection works.

Evaluation: General environmental changes as a result of encroachment activities in the GREAT I Region include changes in the surface area of the river and islands (Simons et al. 1976), floodplain, vegetation, water level, land use and water habitats (Simons et al. 1976; Olson and Meyer 1976, Helms 1968). Bianchi (1975), however, concluded that soil and water conservation practices must be maintained to preserve the environment. Nonetheless, Fremling (1977) predicts that by 1999, substantial portions of the river area will be lost to sedimentation. Meanwhile, public awareness and involvement in issues such as water quality, flooding, sedimentation and water and soil conservation practices is continuing (U.S. Fish and Wildlife Service 1976).

Recommendations: See Recommendations for 1. Industrial, 2. Municipal, 3. Agricultural and 4. Recreational enroachment activities for all three GREAT Regions.

Literature Cited:

Bianchi, A. 1965. A history of Winona. Soil and Water Cons. Dist. Research paper presented to Graduate Council. Winona State College. Winona, MN. 66 pp.

Fremling, C. 1977. Mississippi River - 1999. A paper presented at the annual meeting of Upper Mississippi River Research Consortium. June 10, 1977. Winona St. University. 5 pp.

Helms, D. 1968. Aquatic habitat of the Mississippi River bordering Iowa. Iowa Cons. Comm. Quart. Biol. Repts. 20 (4): 11-14.

Olson, K. and M. Meyer 1976. Vegetation, land and water surface changes in the upper navigable portion of the Mississippi River basin over the period 1939-1973. U.S. Army Corps of Eng. Phase III, Contr. No. DACW-37-74-C-0043. 150 pp. + App. A-M.

Simons, D., S. Schumm, Y. Chen and R. Beathard. 1976. A geomorphic study of Pool 4 and tributaries of the Upper Mississippi River. CER76-77DBS-SAS-YHC-RMB11. Colo. St. Univ., Ft. Collins, CO.

U.S. Fish and Wildlife Service. 1976. Fish and wildlife technical report. Prep. for the Fish and Wildl. Task Group. Minneapolis - St. Paul Area Level B Study, UMRBC.

b. GREAT II

Information: In addition to the references categorized according to particular types of encroachment activities in the GREAT II Region, 15 references were made which could not be placed in a specific category (Table 47). Pools 11, 14, 15, 16 and 18 were referenced most often. One reference each for Pools 14, 15, and 16 dealt with flood protection works.

Voids. Of the 15 references to general aspects of encroachment activities in GREAT II Region, none were for Pools 20 or 21.

Evaluation: The most comprehensive review of the impacts of encroachment activities due to the operation and maintenance of the navigation system in the GREAT II Region is provided by the U.S. Army Corps of Engineers (1974) Environmental Impact Statement. Helms (1968a,b) describes the habitats and extent of habitat types in pools in GREAT II in the vicinity of Iowa; many of which have been created or modified by a variety of encroachment activities. In addition, various projects are expected to have general types of impacts or involve various types of habitat alternations (U.S. Army Corps of Engineers 1971; 1975a,b).

Recommendations: See Recommendations for 1. Industrial, 2. Municipal, 3. Agricultural and 4. Recreational enroachment activities.

Literature Cited:

Helms, D. 1968a. Aquatic habitat of the Mississippi River navigation Pools 11 and 18. Iowa Cons. Comm., Quart. Bio. Repts., 20 (2): 19-23.

___________. 1968b. Aquatic habitat of the Mississippi River bordering Iowa. Iowa Cons. Comm., Quart. Biol. 20(4): 11-14.

U.S. Army Corps of Engineers. North Central Division. Chicago. 1971. Water resource development in Illinois. Chicago, IL. 138 pp.

________________. 1974. Final environmental impact statement, Pools 11 thru 22, Operations and maintenance, Upper Mississippi River, 9-foot navigation channel. U.S. Army Corps of Engineers. Rock Island, IL.

________________. 1975a. Final Environmental Statement, Fulton, Illinois and vicinity, Local Protection Project. U.S. Army Corps of Engineers, Rock Island, IL.

________________. 1975b. Final Environmental Impact Statement, Milan-Big Island, Illinois, Local Flood Protection. U.S. Army Corps of Engineers, Rock Island, IL.

c. GREAT III

Information: Six general references were reviewed regarding encroachment activities in the GREAT III Region, and 16 others pertained to the Upper Mississippi River not specific to any GREAT Region (Table 48). Five were references for the Lower Stretch.

Voids: Of the 6 general references regarding encroachment activities in GREAT III Region, none were made for Pools 24, 25, or 26 (Table 48.)

Evaluation: Emge (1972) presented a study plan for an environmental inventory of the GREAT III Region and Emge et al. (1974) presented certain of the results; both included information relating to mans' encroachment on the river and use of the flood plain. Stevens et al. (1975) discussed the history of mans' impact on the river morphology which resulted from 150 years of flood protection activities and floodplain use. The Upper Mississippi River Comprehensive Basin Study (1973) provided a comprehensive overview of water resources utilization in this area. Several references dealt with resource planning, legislation and environmental assessment regarding the inclusion of a portion of the Upper Mississippi River in the National Wild and Scenic Rivers System (U.S. Bureau of Outdoor Recreation 1977a,b; U.S. Congress. House. 1977).

Recommendations: See Recommendations for 1. Industrial, 2. Municipal, 3. Agricultural and 4. Recreational enroachment activities.

Literature Cited:

Emge, W. 1972. Study plan for an environmental inventory and assessment of the Mississippi River 9-ft. channel project between St. Louis, Missouri, and Cairo, Illinois. USACE Waterways Experiment Station, Vicksburg, MS. 36 pp.

Emge, W., R. Solomon, J. Johnson, C. Bingham, and B. Colbert. 1974. Physical, Biological, and Chemical Inventory of Twenty-three Side Channels and four River Border Areas, Middle Mississippi River. Army Engineer Waterways Experiment Station. Vicksburg, MS. 621 pp.

Stevens, M., D. Simons, and S. Schumm. 1975. Man-induced changes of Middle Mississippi River. American Society of Civil Engineers. Waterways and Harbors Coastal Engineering Division. Journal 101(2): 119-133. (Period. Art.)

U.S. Bureau of Outdoor Recreation. 1977a. The Upper Mississippi: A wild and scenic river study; final report and environmental impact statement. Ann Arbor, Michigan. 215 pp.

______________. 1977b. Wild and scenic river study, Upper Mississippi River, Minnesota: communication from the Director, Bureau of Outdoor Recreation. Ninety-fifth Congress, first session. House Document 95-217. U.S. Government Printing Office, Washington, D.C. 231 pp.

U.S. Congress. House. 1977. Wild and scenic river recommendation: Upper Mississippi River, Minnesota. Ninety-fifth Congress, first session. House Document 95-164, pt 12. U.S. Government Printing Office, Washington, D.C. 4 pp.

Upper Mississippi River Comprehensive Basin Study. 1973. Water and Related Land Resources. Coordinating Committee, Chicago, IL. 19 pp.

d. Non Upper Mississippi River

Information: A total of 43 references was made regarding general encroachment activities outside the Upper Mississippi River (Table 48).

Voids: Considering that 43 references were cited concerning general aspects of encroachment activities outside the Upper Mississippi River, no voids may exist; however, probably substantially more references are available (Table 48).

Evaluation: Many references included in this category present specific projections of agency plans or reports. Ortholano (1973) reported on a study to develop methods for evaluation of environmental impact associated with water resource developments and to analyze requirements of certain regulations. Darnell et al. (1976) discussed the impacts of floodplain construction and channelization and they indicated that the worst impact was that of direct habitat loss. This conclusion was reinforced by Funk and Robinson (1974) who determined that during the past 90 years, encroachment activities on one section of the lower Missouri River resulted in loss of 50% of the water surface area.

Recommendations: Studies outside the Upper Mississippi River basin may be of value in answering questions or solving problems encountered there. It is suggested that as questions or problems are identified, a carefully designed and specifically oriented literature search would be valuable. Additional information regarding the impacts of encroachment activities, including flood protection works, may be useful in interpreting data from within the Upper Mississippi River.

Literature Cited:

Darnell, R., W. Pequegnat, B. James, F. Benson, and R. Defenbaugh. 1976. Impacts of construction activities in wetlands of the United States. Tereco Corporation, College Station, Texas. 426 pp. EPA/600/3-761045.

Funk, J., and J. Robinson. 1974. Changes in the channel of the Lower Missouri River and effects on fish and wildlife. Missouri Department of Conservation. Aquatic Series No. 11. Jefferson City. 55 pp.

Ortolano, L. 1973. Analyzing the environmental impacts of water projects. Stanford University, Department of Civil Engineering, Palo Alto, CA. 433 pp.

C. Navigation

1. Commercial

a. GREAT I

Information: A total of 12 references were reviewed that mentioned various aspects of commercial navigation activities in the GREAT I Region (Table 49). Of these, nine were considered to be of general nature. Of these nine references, three and two were for Pools 1 and 2, respectively, and one each were for Pools 6, 8, 9 and the entire GREAT I Region. Aside from these, one reference was made regarding suspension of sediments and turbidity in Pool 7 and dealt with hazing of wildlife in Pool 2; and one concerned cold weather effects in Pool 1.

Voids: No references were made regarding wave wash, toxic spills, or displacement and tidal effects aspects of commercial navigation in any pools of GREAT I (Table 49). No references regarding any effects of commercial navigation in GREAT I were made for Pools 3, 4, 5, 5A, or 10.

Evaluation: Most references dealing with the impact of commercial navigation activities are concerned with general impacts of the overall operation of the navigation system, and most emphasize environmental impact assessment in one or a few pools (Claflin 1973a, b; Collingsworth 1973 a,b,c; Collingsworth et al. 1973; Eckblad 1973) or the entire GREAT I Region (U.S. Army Corps of Engineers 1974). These studies were usually designed to identify both impacts and benefits of commercial navigation and to recommend approaches to maximize the benefits while minimizing the impacts. Hesselberg (1971), however, studied the direct impact of river traffic and concluded that high sedimentation rates in channel areas are due to turnover caused by river traffic; and the silt load carried by the current is deposited as the waters are slowed by a dam.

Recommendations: Additional studies should be performed to assess the impacts of commercial and recreational navigation; on fish and wildlife resources. The study sites should include all pools which previously have been poorly studied. Essentially all potential impacts of commercial navigation should be included.

Literature Cited:

Claflin, T. O. 1973a. Final report: Environmental impact assessment study, Pool 7, of the northern section of the Upper Mississippi River, N. Star Res. Inst., Minneapolis, MN.

__________. 1973b. Final report: Environmental impact assessment study, Pool 8, of the northern section of the Upper Mississippi River, N. Star Res. Inst., Minneapolis, MN.

Collingsworth, R. F. 1973a. Final report: Environmental impact assessment study, Pool 1, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

__________. 1973b. Final report: Environmental report assessment study, Pool 2, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

__________. 1973c. Final report: Environmental impact assessment study, St. Croix River Pool, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

Collingsworth, R. F., B. J. R. Gudmundson, W. L. K. Schwarz and C. W. Rudelius. 1973. Environmental impact assessment study: St. Anthony Falls Upper and Lower pools, Pool 1, Pool 2, and lower 25 miles of the St. Croix and Minnesota rivers. N. Star Res. Inst., Minneapolis, MN.

Eckblad, J. 1973. Final report: Environmental impact assessment study, Pool 9, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

Hesselberg, G. 1971. Sedimentation rates, particle size and distribution and sedimentation depths on Navigation Pool no. 7. including Lake Onalaska. M.S. Thesis. St. Mary's College, Winona, MN.

U.S. Army Corps of Engineers. 1974. Draft Environmental Impact Statement: Operation and maintenance Upper Mississippi River, Head of Navigation to Guttenberg, Iowa. U.S. Army Corps of Engineers. St. Paul, MN.

b. GREAT II

Information: A total of 23 references was made for various aspects of commerical navigation activities in the GREAT II Region (Table 50). Of these, 13 were considered to be of a general nature. Of these 13 references, two were for Pool 19, and one each for Pools 12 through 18, 20 through 22 and the entire GREAT II Region. Aside from these, two references were made regarding hazing of wildlife in Pool 19. There were eight references made, however, regarding cold weather effects. Most, (3 each) were in Pool 19 and the entire GREAT II Region.

Voids: No references were made regarding toxic spills in any pools of GREAT II (Table 50). No references regarding the effects of commerical navigation in GREAT II were made for Pool 11. Essentially no references were made for Pools other than Pool 19, and essentially no aspects of commerical navigation were referred to except cold weather effects or general aspects.

Evaluation: The U.S. Army Corp of Engineers (1974) Environmental Impact Statement on the operation and maintenance of the navigation system in GREAT II does not comment directly on the impact of navigation on the environment, but it includes discussion on impacts which result because of navigation, and provides a valuable overview of the situation. Dunham (1970), however, performed aerial surveys to evaluate recreational use of this area and demonstrated an interaction between commerical boat traffic and recreation; and Thompson (1973) demonstrated that waterfowl in Pool 19 modify their movements because of various disturbances in the river. In the case of the Fort Madison commercial harbor development to enhance commercial navigation the Izaak Walton League was opposed to the loss of fish and wildlife habitat (Anonymous 1972). Most other references regarding commercial navigation dealt specifically with

the problem of winter navigation in the GREAT II Region. Cawley (1978) provided a description of biological implications of winter navigation, and the Midwest Research Institute (1978) demonstrated numerous environmental and sociological concerns of year-round navigation, and pointed out that a demonstration project was required. The U.S. Army Corps of Engineers (1967a,b) provided economic justification for winter navigation. Ashton (1974), Ashton et al. (1973) and U.S. Army Corps of Engineers (1976) dealt with technical aspects of winter navigation which may have environmental effects.

Recommendation: See Recommendations for a. GREAT I.

Literature Cited:

Anonymous. 1972. Walton League opposes dredge and fill projects on Upper Mississippi River. Outdoor America. 37(1):9.

Ashton, G. D. 1974. Evaluation of Ice Management Problems Associated with Operation of a Mechanical Ice Cutter on the Mississippi River. Cold Regions Res. and Eng. Lab., Hanover, NH. Coast Guard, Washington, D.C.

Ashton, G. D., S. L. Denhartog, and B. Hanamoto. 1973. Ice-breaking by tow on the Mississippi River. Cold Regions Res. and Eng. Lab. Hanover, NH. 77 p.

Cawley, E. T. 1978. Biological impacts study of winter navigation, Pool 12, Upper Mississippi River. Loras College, Environmental Research Center. Dubuque, Iowa. 14 pp.

Dunham, L. 1970. Aerial recreation survey of the Mississippi River. Ill. Dept. Cons., Div. of Fisheries. 14 pp.

Midwest Research Institute. 1978. Environmental and social considerations of Mississippi River, year-round navigation program; final report. Kansas City, Missouri. 72 pp.

Thompson, D. 1973. Feeding ecology of diving ducks on Keokuk Pool, Mississippi River. Wildlife Manage. 37(3): 367-381.

U.S. Army Corps of Engineers, Army Engineer District, Rock Island. 1967a. Review of reports on Upper Mississippi River for year-round navigation; report of public hearings. Rock Island, IL. Various pagings.

______________. 1967b. Ice conditions, winter 1965-1966; after-action report. Rock Island, IL. Various pagings.

______________. 1974. Final environmental impact statement, Pools 11 thru 22, operations and maintenance, Upper Mississippi River 9-foot navigation channel. U.S. Army Corps of Engineers. Rock Island, IL.

______________. 1976. Quantitative and qualitative analysis of pre and post wildlife habitat conditions resulting from nine-foot navigation channel, Upper Mississippi River (Pools 11-22). Rock Island District, Rock Island, IL.

c. GREAT III

Information: Four references were made concerning various aspects of commerical navigation activities in the GREAT III Region (Table 51). Of these, one was for the Lower Stretch and one was for the entire GREAT III Region; and both were considered to be of a general nature. Aside from these, two references were made regarding cold weather effects in the entire GREAT III Region.

Voids: No references were made regarding wave wash, suspension of sediments and turbidity, toxic spills, hazing of wildlife, or displacement and tidal effects aspects of commerical navigation in any pools or the Lower Stretch of the GREAT III Region (Table 51). No references regarding the effects of commerical navigation in GREAT III were made for Pools 24, 25, or 26.

Evaluation: Dunham (1970) surveyed the intensity of recreational use of the Mississippi River bordering Illinois and commented on the effects of commerical navigation on recreational activities. Ashton et al. (1973) described various approaches and results of icebreaking by tow, while the Midwest Research Institute (1978) examined, categorized, and elucidated various comments pertinent to the Mississippi River extended navigation season. These included environmental and social concerns expressed by public and governmental agencies.

Recommendations: See Recommendations for a. GREAT I.

Literature Cited:

Ashton, G. S., Denhartog, and B. Hanamoto. 1973. Ice-breaking by tow on the Mississippi River. Cold Regions Res. and Eng. Lab., Hanover, NH. 77 pp.

Dunham, L. 1970. Aerial Recreation Survey of the Mississippi River. Ill. Dept. Cons., Div. of Fisheries. 14 pp.

Midwest Research Institute. 1978. Environmental and social considerations of Mississippi River, year-round navigation programs; final report. Kansas City, Missouri. 72 pp.

d. Upper Mississippi River

Information: A total of 19 references was made for various aspects of commerical activities in the Upper Mississippi River not specific to any GREAT Region (Table 51). Of these, nine were considered to be of general nature. Aside from these, one reference was made regarding wave wash; four references were made regarding suspension of sediments and turbidity; and two were concerned with cold weather effects.

Voids: No references were made regarding toxic spills in the Upper Mississippi River.

Evaluation: Christianson (1974, 1975) and Waelti (1974) reviewed and discussed the economic and environmental values of commercial navigation on the Upper Mississippi River. Mueller (1977) pointed out that where commercial navigation is heaviest in the Upper Mississippi River, nearly all aquatic vegetation is eliminated by the fluctuating water level and sedimentation and implied that low commerical catches in certain areas were due to high commerical navigation. Several references correlated tow traffic on the Upper Mississippi River with resuspension and movement of bed materials (Karaki and Van Hoften 1974, Johnson 1976, Link and Williamson 1976).

Recommendations: See Recommendations for a. GREAT I.

Literature Cited:

Christianson, R. 1974. Commercial Navigation on the Upper Mississippi River: An Economic Review of its Development and Public Policy Issues Affecting Minnesota. Minnesota Univ., Minneapolis, Water Resources Research and Technology. Washington, D.C. 125 pp.

________________. 1975 Commerical Navigation on the Upper Mississippi River: Economic and Environmental Choices. Minnesota Univ., St. Paul Dept. of Agriculture and Applied Economics. Office of Water Research and Technology. Washington, D.C. 8 pp.

Johnson, J. 1976. Effects of Tow Traffic on the Resuspension of sediments and on Dissolved Oxygen Concentrations in the Illinois and Upper Mississippi River under Normal Pool Conditions. Army Engineers Waterways Experiment Station. Vicksburg, MS. 185 pp.

Karaki, S. and J. Van Hoften. 1974. Resuspension of Bed Material and Wave Effects in the Illinois and Upper Mississippi Rivers caused by Boat Traffic. CERT4-75 SK-JV9, Colorado State Univ., Ft. Collins, CO.

Link, L., Jr., and A. Williamson Jr. 1976. Use of automated remote sensing techniques to define the movement of two-generated suspended material plumes on the Illinois and Upper Mississippi Rivers. Army Engineer Waterways Experiment Station, Vicksburg, MS. 71 pp.

Mueller, A. 1977. Navigation effects in the open river. Proc. 33rd. Ann. UMRCC Mtg. pp. 59-64.

Waelti, J. 1974. Flood Control, Navigation, and Other Alternative Water Resources Policies in Minnesota. Minnesota Univ., Minneapolis. Water Resources Research Center. Office of Water Resource Research, Washington, D.C. 27 pp.

e. Non Upper Mississippi River

Information: A total of 90 references were made regarding various aspects of commerical navigation activities in areas outside the Upper Mississippi River (Table 51). Of these, most (52 references) dealt with some aspects of cold weather effects on navigation on the environment, and 26 references dealt witth general aspects of commerical navigation.

Voids: Of the 90 references made regarding the various aspects of commerical navigation activities outside the Upper Mississippi River, only 5, 4, 2 and 1, dealt with aspects of suspension of sediments and turbidity, displacement and tidal effects, toxic spills, and wave wash, respectively (Table 51). No references were made regarding hazing of wildlife.

Evaluation: Many references in this category deal with plans or reports concerning specific projects or agency reports, but Mooney (1964) provided an analysis of barge traffic and discussed the problem and economic implications of rail-barge competition in the Mississippi River system.

There is a great deal of interest in winter navigation and the effects of cold and ice on winter navigation. Included in these references are a number of references which specifically address certain aspects of this problem, particularly methods of breaking ice or preventing its formation. Similarly, the effects of ship passage on the channel is a concern. Stout and Welch (1977) analyzed the Illinois River navigation system and discussed the problem of wave wash and bank erosion. Longuet-Higgins (1976) used a model to measure breaking waves and their action, while Liou and Herbich (1976) and Wilson (1973) studied bottom erosion and sediment movement induced by ships in waterways.

The U.S. Federal Water Pollution Control Administration (1967) reported that pollution by watercraft in the Missouri Basin resulted largely from discharge of sewage, dunnage and other wastes and spills of transported materials or oil.

Recommendations: Studies outside the Upper Mississippi River basin may be of value in answering questions or solving problems encountered there. It is suggested that as questions or problems are identified, a carefully designed and specifically oriented literature search would be valuable in interpreting data obtained from within the Upper Mississippi River or solving problems encountered there.

Literature Cited:

American Society of Civil Engineers. Task Committee on Hydromechanics of Ice. 1974. River - ice problems; a state-of-the-art survey and assessment of research needs. Its Hydraulic Division. Journal 100 (NHY1):1-15.

Frankenstein, G. 1975. International symposium on ice problems. 3rd. Dartmouth College. Hanover, NH. August 28-21. Proceedings. 627 pp.

Habercon, G., Jr. 1975. Icebreakers and icebreaking; a bibliography with abstracts. National Technical Information Service. Springfield, VA. 93 pp.

Liou, Y. and J. Herbich. 1976. Sediment movement induced by ships in restricted waterways. Texas A&M University. Department of Civil Engineering Report COE 188. College Station 85 pp.

Longuet-Higgins, M. 1976. Breaking waves - in deep or shallow water. In: Symposim on naval hydrodynamics. 10th. Cambridge, Massachusetts. June 24-28, 1974. Proceedings: 597-605.

Mooney, C. 1964. Rail-barge competition in the Mississippi Valley: An empirical study of inland water transportation. Ph.D. Thesis. Washington University, St. Louis, MO. 152 pp.

Stout, G. and P. Welch. 1977. Future problems and water resources research needs of the Illinois River System. University of Illinois. Water Resources Center. Champaign-Urbana. 220 pp.

U.S. Federal Water Pollution Control Administration. 1967. Pollution of navigable waters by the operation of watercraft in the Missouri Region. Kansas City, MO. 54 pp.

Wilson, K. 1973. Report on a hydraulic model study of bottom erosion caused by the passage of vessels through through channels with limited bottom clearance. Queen's University Department of Civil Engineering. Kingston, Ontario. 20 pp.

2. Recreational

a. GREAT I

Information: A total of 17 references was made from various aspects of recreational navigation activities in the GREAT I Region (Table 52). Of these, 16 were considered to be of general nature; and, of these references, 4, 3, and 2 were for Pools 1, 2, and 9, respectively. One each were for Pools 3-8. Aside from these, one reference was made regarding wave wash in Pool 4.

Voids: No references were made regarding hazing of wildlife, suspension of sediments or turbidity aspects of recreation navigation in any pools of GREAT I (Table 52). No references regarding any effects of recreational navigation in GREAT I were made for Pool 10.

Evaluation: References made regarding the impacts of recreational navigation deal largely with only the general aspects rather than specific or direct impacts of recreational navigation. (Collingsworth 1973 a,b,c; Collingsworth et al. 1973). These typically provide an overview environmental impact evaluation; however, the U.S. Army Corps of Engineers (1971) comments specifically regarding a small boat harbor development in Lake Pepin.

Recommendation: See Recommendations for 1. Commerical Navigation.

Literature Cited:

Collingsworth, R. F. 1973a. Final report: Environmental impact assessment study, Pool 1, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

____________. 1973b. Final report: Environmental report assessment study, Pool 2, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

____________. 1973c. Final report: Environmental impact assessment study, St. Croix River Pool, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

Collingsworth, R. F., B. J. R. Gudmundson, W. K. K. Schwarz and C. W. Rudelius. 1973. Environmental impact assessment study: St. Anthony Falls Upper and Lower pools, Pool 1, Pool 2, and lower 25 miles of the St. Croix and Minnesota rivers. N. Star Res. Inst., Minneapolis, MN. 164, 188, 211, 141, and 169 pp., respectively.

U.S. Army Corps of Engineers. 1971a. Small-Boat Harbor, Mississippi River at Pepin, Wisconsin. Final environmental impact statement. Army Engineer District, St. Paul, MN. 34 pp.

b. GREAT II

Information: A total of 14 references were reviewed pertaining to aspects of recreational navigation activities in the GREAT II Region (Table 53). Of these, 12 were considered to be of general nature; and of these twelve references, one each were for Pools 12 through 22 and 1 was for the entire GREAT II Region. Aside from these, two references were made regarding hazing of wildlife in Pool 19.

Voids: No references were made regarding wave wash, suspension of sediments or turbidity aspects of recreational navigation in any pools of GREAT I (Table 53). No references regarding the effects of recreational navigation in GREAT II were made for Pool 11.

Evaluation: Dunham (1970) performed a series of aerial surveys to assess recreational use and activities in the Mississippi River. Most fishing occurred in Pools 13 and 15, and most camping was on Pool 13. Thornburg (1971, 1973) demonstrated that waterfowl movements were greatly influenced by hunter activities; and Harker (1978) commented on recreational use of the Mississippi River and the adverse impacts of recreational use on riparian vegetation and floodplain use.

Recommendation: See Recommendations for 1. Commerical Navigation.

Literature Cited:

Dunham, L. 1970. Aerial recreation survey of the Mississippi River. Ill. Dept. Cons., Div. of Fisheries. 14 pp.

Harker, G. 1978. GREAT II (Great River Environmental Action Team). Recreational Work Group - Literature review. Western Illinois University. Macomb, IL.

Thornburg, D. 1971. Flock behavior of diving ducks on Keokuk Pool, Mississippi River. M. S. Thesis. Iowa State Univ. Ames, IA. 64 pp.

__________. 1973. Diving duck movements on Keokuk Pool Mississippi River. J. Wildl. Manage. 37(3). 382-389.

c. GREAT III

Information: Only three references were reviewed concerning the various aspects of commerical navigation activities in the GREAT III Region or the Upper Mississippi River in general (Table 54). In addition, eight references were from areas outside the Upper Mississippi River.

Voids: No references were made regarding hazing of wildlife, wave wash, suspension of sediments or tubidity resulting from recreational navigation in any pools or the Lower Stretch of GREAT III (Table 54).

Evaluation: Based on his aerial recreational surveys, Dunham (1970) reported that the heaviest pleasure craft usage of the Mississippi River in the vicinity of Illinois was in Pool 26. Karaki and Van Hoften (1974), in their review of resuspension of bed material and wave effects by boat traffic in the Upper Mississippi River, included comments on the effects of recreational boat traffic as well as commerical boat traffic. The Pacific Northwest Water Laboratory (1967) presented information on the extent of recreational boating and supporting families and regulations. Cirillo and Wolsko (1973) described procedures to evaluate air pollution emissions from various transportation systems, including outboard and inboard boat engines. Moss (1977) reported that boat disturbances did not significantly contribute to turbidity. Yousef (1974), however, reported that agitation and mixing by motorboats did increase turbidity and destratified lakes.

Recommendations: See Recommendations for 1. Commercial Navigation.

Literature Cited:

Cirillo, R. and T. Wolsko. 1973. Handbook of air polluted emissions from transportation systems. U.S. Argonne National Laboratory. Lemont, IL. 179 pp. ANL/ES-28.

Dunham, L. 1970. Aerial recreational survey of the Mississippi River. Ill. Dept. Cons., Div. of Fisheries. 14 pp.

Karaki, S. and J. Hoften. 1974. Resuspension of bed material and wave effects on the Illinois and Upper Mississippi Rivers caused by boat traffic. CERT4-75 SK-JV9. Colorado State Univ., Ft. Collins, CO.

Moss, B. 1977. Conservation problems in Norfolk broads and rivers of East Angolia, England: phytoplankton, boats, and the causes of turbidity. Biological Conservation 12(2):95-114.

Pacific Northwest Water Laboratory. 1967. Pacific Northwest Watercraft pollution study. Corvallis, OR. 430 pp. PB-230 465/7.

Yousef, Y. 1974. Assessing effects on water quality by boating activity. National Environmental Research Center, Office of Research and Development. Cincinnati, OH. 59 pp.

D. General Water Quality

1. GREAT I

Information: One hundred twelve references regarding general water quality of the GREAT I Region were compiled and reviewed. Of these, 107 dealt with water quality surveys and only five references were specific to water quality regulations (Table 55). Of the references made regarding specific aspects of water quality, approximately 80% dealt with DO (dissolved oxygen), BOD (biological oxygen demand) and temperature, with the remaining references concerning selected nutrients, pH, total and fecal coliform, turbidity and/or heavy metals. All pools, except Pool 10, were specifically referred to in these studies, though some articles included several pools. Thirty articles were of general nature and included the entire GREAT I Region. Pool 1 was cited most often (22% of the total), followed by Pools 2, 6 and 7.

Voids: Although 107 references were available relating to general water quality in the GREAT I Region, many parameters associated with water quality evaluations were not tested in each pool. Even though DO and BOD may have been tested in every pool, other parameters such as nutrient concentration, pH, turbidity, heavy metals and total and fecal coliform were analyzed in only some of the pools. Pool 10 was the only pool where specific references for water quality analysis were absent. Pools receiving the fewest references were 5A and 9.

Evaluation: Larson et al. (1976), Lewis (1970) and Waelti and Lewis (1971) conducted surveys in Pool 1 to note changes in water quality. These studies revealed generally mixed changes in the quality of the Mississippi River near the Minneapolis-St. Paul area. Collingsworth (1973a, 1973b, 1973c) identified the source of these impacts on water quality and assessed their

effects on the natural environment. Larson et al. (1976) reported that water quality has deteriorated as a result of inefficient wastewater treatment facilities in Pool 1. Fremling (1964, 1970) has shown that mayfly populations, which are an excellent index of water quality, have been severely reduced by polluted conditions 30 miles below the Twin-Cities area. A comprehensive water quality program has been undertaken in the Minneapolis-St. Paul area to achieve proper dissolved oxygen concentrations as requested by the Federal Water Pollution Control Act Amendments of 1972 (Water Resources Engineers, Inc. 1975). Baur (1967) and Knapik et al. (1970) have conducted water quality surveys in Pool 6 based on fecal and total coliform densities. Hannon (1967) demonstrated that fecal coliforms in Pool 6 accounted for less than 4.5% of the total coliform density. Hall (1969) showed that the single most important factor affecting water quality in terms of coliform density was temperature, followed by turbidity and current. It was reported by Gentille (1968) that excessive amounts of nutrients were affecting water quality between Lake Pepin and LaCrosse, Wisconsin. Clark (1974) and Strodthoff (1978) showed that Pool 7 was a nutrient trap for nitrates and phosphates. Incoming nutrients were being assimilated into the abundant plant growth and then trapped in sediments, eventually lowering DO levels at certain times of the year.

Water chemistry studies (Claflin 1973, Eckbald 1973, and McDonald 1972) in Pools 8 and 9 indicated that water quality is generally good, although there are limited stretches of the river where deteriorated water quality conditions occur. McDonald (1972) reported that in areas of Pools 8 and 9 where water quality has deteriorated, oxygen concentrations were usually adequate for fish life. The Federal Water Pollution Control Administration (1967, 1968, 1969 and 1974) has investigated the water quality along the Upper

Mississippi River (GREAT I Region), gathering information on sources and quantities of waste discharges. Water quality standards were recommended by the Administration for treatment of waste discharge, disinfection of bacteriological pollution and maximum permisible levels of phenols and radioactivity.

Recommendations: Studies should be performed in every pool to obtain reference water quality information. Routine water quality parameters and methodologies should also be implemented so that water quality data are comparable among pools. Analysis of standard water quality parameters such as DO, BOD, pH, etc. would establish a reference data base for future industrial sites or other activities.

Literature Cited:

Baur, R. J. 1967. A survey of the total coliform density in Pool 6 of the Mississippi River for fall and winter seasons. B.A. Thesis, St. Mary's College, Winona, MN. 33 pp.

Claflin, T. O. 1973. Final report: Environmental impact assessment study. Pool 8, of the northern section of the Upper Mississippi River, N. Star Res. Inst., Minneapolis, MN.

Clark, S. H. 1974. Determination of the relative state of eutrophy of navigation Pool 7 in the Upper Mississippi River by means of an algal assay procedure. M.S. Thesis, Univ. of Wis., LaCrosse, WI.

Collingsworth, R. F. 1973a. Final report: environmental impact assessment study, Pool 1, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

__________. 1973b. Final report: environmental report assessment study, Pool 2, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

__________. 1973c. Final report: environmental impact assessment study, St. Croix River Pool, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

Eckblad, J. W. 1973. Final report: environmental impact assessment study, Pool 9, of the northern section of the Upper Mississippi River. N. Star Res. Inst., Minneapolis, MN.

Federal Water Pollution Control Administration. 1964. Proceedings of the conference in the matter of pollution of the interstate and interstate waters of the Upper Mississippi River and its tributaries - Minnesota - Wisconsin.

__________. 1967. Proceedings of the conference in the matter of pollution of the interstate and intrastate waters of the Upper Mississippi River and its tributaries - Minnesota - Wisconsin.

__________. 1968. Pollution of the Upper Mississippi River and its tributaries - (Minnesota-Wisconsin). Proceedings of progress evaluation meeting of conference held in Minneapolis, Minnesota on April 30, 1968. Washington, D. C. 382 pp.

__________. 1969. Progress evaluation meeting (2nd) in the matter of the interstate and interstate waters of the Upper Mississippi River and its tributaries - States of Wisconsin and Minnesota. Held at Minneapolis, Minnesota on 22 July 1969. Washington, D. C. 362 pp.

__________. 1974. Summary and pollution abatement recommendations for the Upper Mississippi River and major tributaries. St. Paul, Minn. Twin Cities Upper Mississippi River Project. 60 pp.

Fremling, C. R. 1964. Mayfly distribution indicates water quality on the Upper Mississippi River. Science 146(3648):1164-1166.

__________. 1970. Mayfly distribution as a water quality index. Published by EPA - Water Quality Office. 44 pp.

Gentille, J. M. 1968. A study of the phosphorous levels of the Mississippi River and adjoining streams in Pool 6. B. A. Thesis, St. Mary's College, Winona, MN. 38 pp.

Hall, T. R. 1966. Determination of the multiple correlation between total and fecal coliforms with temperature, turbidity, and current in Pool 6 of the Mississippi River, Winona, Minnesota. M.S. Thesis, St. Mary's College, Winona, MN. 25 pp.

Hannon, M. R. 1967. Determination of fecal-coliform densities in Pool 6 of Mississippi River. B.A. Thesis, St. Mary's College, Winona, MN. 27 pp.

Knapik, R. V. and Br. R.Thomas. 1970. Determination of fecal and total coliform densities in a slough of Pool 6 in the Mississippi River. M.S. Thesis, St. Mary's College, Winona, MN.

Carson, S. P., W. B. Mann, IV, T. D. Steel and R. H. Susag. 1976. Graphic and analytical methods for assessment of stream-water quality - Mississippi River in the Minneapolis-St. Paul metropolitan area. Minnesota Geological Survey. St. Paul, Minn. Water Resources Div. Metropolitan Waste Control Commission, St. Paul, MN. 63 pp.

Lewis, R. C. 1970. The marginal costs of alternative levels of water quality in the Upper Mississippi River. Water Resources Research Center. M.S. Thesis, U. of Minn. 59 pp.

McDonald, D. B. 1973. Some chemical and biological characteristics of the Mississippi River bordering Iowa. AICHE Symp. Ser. Water 69(129):380-390.

Rodthoff, K. M. 1978. Nitrogen and phosphorus exchanges between water, sediment and macrophytes in Lake Onalaska of Pool 7, Upper Mississippi River 1975 to 1976. M.S. Thesis, Univ. of Wis., LaCrosse, WI. 113 pp.

Waelti, J. J. and R. C. Lewis. 1971. The water quality controversy in Minnesota and the marginal costs of alternative levels of water quality in the Upper Mississippi River. Minnesota Univ. Minneapolis. Water Resources Research Center. 22 pp.

Water Resource Engineers, Inc. 1975. Water quality analysis Upper Mississippi River Basin. Walnut Creek, Calif. National Committee on Water Quality, Washington, D. C. 115 pp.

2. GREAT II

Information: Sixty references referring to general water quality of the GREAT II Region were compiled and reviewed. Forty nine of these dealt with water quality surveys and only 10 references were specific to water quality regulations (Table 56). All water quality surveys references dealt with DO (dissolved oxygen) and BOD (biological oxygen demand) analysis while other water quality parameters such as selected nutrients concentration, pH, turbidity, heavy metals, alkalinity and bacterial concentration were analyzed to a lesser extent. All pools, except Pools 21 and 22, were specifically referred to in these studies. Twenty-two articles were of general nature and included the entire GREAT II Region. Pool 14 was cited most often (20% of the total), followed by Pools 18 and 19.

Voids: Although there are 49 references available relating to general water quality in the GREAT II Region many parameters associated with water quality evaluations were not tested in each pool. Although DO and BOD may have been tested in every pool, other parameters such as nutrient concentration, pH, turbidity, heavy metals, alkalinity, and bacterial concentration were analyzed in only some of the pools. Pools 21 and 22 had no specific references for water quality analyses. Pools 12, 13, 15, 16, 17 and 20 had the fewest references (less than 4 per pool).

Evaluation: Water quality surveys of the Mississippi River from Dubuque to below Keokuk, Iowa indicated that more intensive studies be conducted at a member of areas where evidence of water pollution occurred (Federal Water Pollution Control Administration 1969a). The U.S. Department of the Interior (1969) reported that the Mississippi River was biologically degraded below three Dubuque outfalls. Coffey and Rademacher (1962) and Gakstatter and Morris (1969) have shown that in heavily

populated areas (Quad-Cities) the Mississippi River water quality was reduced with increases in bacterial concentrations. Water quality investigations in the Burlington and Ft. Madison, Iowa areas of Pool 19 showed that industrial and sewage waste discharges were causing elevated fecal coliform counts as well as significant depressions in DO concentrations (Gakstatter and Morris 1970, Iowa State Hygienic Laboratory 1969a). Iowa State Hygienic Laboratory (1969,a,b,c, and d) has indicated that the deterioration in water quality throughout most of the GREAT II Region has mainly resulted from industrial discharges and inefficient waste treatment facilities. Heffelfinger (1973) has shown that river flows would also influence water quality. High river flows have resulted in increases in suspended solids which are responsible for high levels of chemical oxygen demand (COD), total phosphorus and heavy metals (Delfino 1977). McDonald (1973) reported that most areas in the GREAT II Region where water quality has deteriorated, oxygen concentrations were usually adequate for fish life. Federal and state agencies have investigated the water quality in the GREAT II Region of the Mississippi River and have recommended plans for implementation and enforcement of water quality standards. (Federal Water Pollution Control Administration 1969, 1974; Iowa Water Pollution Control Commission 1966, 1967, 1968, 1969).

Recommendations: Survey studies should be performed in every pool to obtain reference water quality information. Routine water quality parameters and methodologies should also be implemented so that water quality data can be comparable among pools. Standard water quality analyses such as DO, BOD, pH, etc. would establish a data base over time in event of future industrial sites or other activities.

Literature Cited:

Coffey, P. J. and J. M. Rademacher. 1962. Report of Water Quality Survey of Mississippi River from Clinton, Iowa, to Rock Island, Illinois. Sanitary Engineering Center, Cincinnati, OH. 63 pp.

Delfino, J. J. 1977. Effects of river discharge and suspended sediment on water quality in the Mississippi River. J. Environ. Sci. & Health. 12(3): 79-95.

Federal Water Pollution Control Administration. 1969a. Mississippi River Reconnaissance, Report of Sampling in the Vicinity of Dubuque, Iowa, and the Tributaries from Above Dubuque to Below Keokuk, Iowa, in both Iowa and Illinois. Chicago, IL. Lake Michigan Basin Offices. 169 pp.

_____________. 1969b. Conference to Consider the Iowa Water Quality Standards for the Mississippi River Basin Interstate Waters - State of Iowa. Held at Davenport, Iowa on 8-9 April 1969. Washington, D.C. 668 pp.

_____________. 1974. Water Quality Standards Conference, State of Iowa. Iowa Convening April 8, 1969, Davenport, Iowa. Chicago, IL. Great Lakes Region. 66 pp.

Gakstatter, J. H. and R. L. Morris. 1969. Mississippi River water quality survey report at Burlington, Iowa. State Hygienic Laboratory Report, University of Iowa.

_____________. 1970. Mississippi River water quality survey report at Burlington, Iowa. State Hygienic Laboratory Report 70-41. University of Iowa.

Iowa State Hygienic Laboratory. 1969a. Mississippi River water quality survey report - Davenport, Iowa - river miles 464.0 - 493.0. Report No. 70-7. Iowa City, IA. 48 pp.

_____________. 1969b. Mississippi River water quality survey report. Muscatine, Iowa area - river miles 439.5 - 456.3. Submitted to the Iowa Water Pollution Control Commission. 32 pp.

_____________. 1969c. Mississippi River water quality survey report. Clinton, Iowa area - river miles 501.2 - 517.6. Submitted to the Iowa Water Pollution Control Commission. 32 pp.

_____________. 1969d. Mississippi River water quality survey report - Fort Madison, Iowa area - river miles 377.3 - 383.3. Submitted to the Iowa Water Pollution Control Commission. Iowa City, IA. Mimeo. 29 pp.

Iowa Water Pollution Control Commission. 1966. Iowa water pollution control law-Code of Iowa 1966. (Printing of chapters 455B, water pollution control referred to in 455.22 - pesticides, 206.3, subsection 2d and miscellaneous provisions.) State Dept. of Health, Des Moines, IA. 15 pp.

________________. 1967. Water quality criteria and plan for implementation and enforcement for the surface waters of Iowa. Adopted by the Iowa Water Pollution Control Commission, State Dept. of Health, May 1967. Des Moines, IA. 90 pp.

________________. 1968. Water quality criteria and plan for implementation and enforcement for the surface waters of Iowa. Adopted by the Iowa Water Pollution Control Commission. State Dept. of Health, May 1967. Des Moines, IA. (Revised June 1, 1968.) 89 pp.

________________. 1969. Statement - in support of the Iowa water quality standards and plan for implementation and enforcement - Mississippi River basin. Iowa Water Pollution Control Commission, State Dept. of Health. Des Moines, IA. April 1969. 20 pp.

McDonald, D. B. 1973. Some chemical and biological characteristics of the Mississippi River bordering Iowa. AICHE Symp. Ser. Water 69(129): 380-390.

U.S. Department of the Interior. 1969. Mississippi River Study. Report of Sampling from Dubuque to Bellevue, IA.

3. GREAT III

Information: Twenty-two references referring to general water quality of the GREAT III Region were compiled and reviewed. Of these seventeen dealt with water quality surveys, and five references were specific to water quality regulations (Table 57). All water quality survey references dealt with DO (dissolved oxygen) and BOD (biological oxygen demand) analysis while other water quality parameters such as selected nutrient concentration, pH, turbidity, heavy metals, alkalinity, suspended solids, and bacterial concentration were analyzed to a lesser extent. All pools and the Lower Stretch were specifically referred to in these studies. Eight articles were of general nature and included the entire GREAT III Region. The Lower Stretch was the area most cited (32% of the total).

Voids: Although there are 22 references available relating to general water quality in the GREAT III Region, many parameters associated with water quality evaluations were not tested in each pool or Lower Stretch. Although DO and BOD were tested in every pool and the Lower Stretch, other parameters such as nutrient concentration, pH, turbidity, heavy metals, alkalinity and bacterial concentration were analyzed in only some of the pools. Pools 24, 25 and 26 had less than 4 references per pool.

Evaluation: Limited information was available on water quality of the Upper Mississippi River in the GREAT III Region. Colbert et al. (1975, 1976) has attempted to establish a data base for the physical, chemical and biological components of the aquatic system in Pools 24, 25 and 26. *In situ* measurements were made for DO, temperature, total alkalinity, pH, turbidity and settleable solids. Bi-State Development Agency (1954) and Kittrell (1958) compiled water quality information on possible sources and

magnitude of water pollution in the St. Louis area. Fremling (1964, 1970) has shown that mayfly populations, which are an excellent index of water quality have been severely reduced by polluted conditions 300 miles below St. Louis. Bi-State Development Agency (1954) has suggested that reduced water quality has resulted from industrial discharges and inefficient waste treatment.

Recommendations: Survey studies should be performed in every pool to obtain reference water quality information. Routine water quality parameters and methodologies should also be implemented so that water quality data can be comparable among pools. Standard water quality analyses such as DO, BOD, pH, etc. would establish a data base over time in event of future industrial sites or corps activities.

Literature Cited:

Bi-State Development Agency. 1954. Mississippi River Pollution Investigations. St. Louis Metropolitan Area. 378 pp.

Colbert, B. K., J. E. Scott, H. Johnson, and R. C. Solomon. 1975. Environmental Inventory and Assessment of navigation Pools 24, 25 and 26, Upper Mississippi and Lower Illinois Rivers. An Aquatic Analysis. Army Engineer Waterways Experiment Station, Vicksburg, MS. 368 pp.

______________. 1976. Environmental inventory and assessment of navigation Pools 24, 25 and 26, Upper Mississippi and Lower Illinois Rivers: and aquatic analysis. USACE Waterways Experiment Station, MS. Final Rept. COL002.

Fremling, C. R. 1964. Mayfly distribution indicates water quality on the Upper Mississippi River. Science 146(3648): 1164-1166.

______________. 1970. Mayfly Distribution as a Water Quality Index. Published by EPA - Water Quality Office. 44 pp..

Kittrell, F. W. 1958. Pollution of Interstate Water of the Mississippi River in the St. Louis Metropolitan Area. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Prepared in cooperation with Missouri State Div. of Health, Illinois State Sanitary Water Board, and the Bi-State Development Agency of the Missouri-Illinois Metropolitan Area. 32 pp.

4. Upper Mississippi River

Information: Forty-four references referring to water quality of the Upper Mississippi River not specific to any of the GREAT Regions were compiled and reviewed (Table 57). Of these, 41 dealt with water quality surveys and only three references were specific to water quality regulations. All water quality surveys references were of general nature with no specific data concerning the various pools. Most of the water quality information was directed towards the general condition of the Upper Mississippi River as well as improving the water quality management and regulations of the river.

Voids: Although there are 44 water quality references available for the Upper Mississippi River, the majority of this information is directed towards the general trends of the river with no references to specific pools.

Evaluation: General water quality of the Upper Mississippi River has been influenced primarily with increased industrial and municipal waste discharges and inefficient waste treatment facilities (Gakstatter and Morris 1970, Larson et al. 1976). The Upper Mississippi River Comprehensive Basin Study (1970) has reported that 75 major water quality control problems, resulting from municipal and industrial waste discharges exist in the Upper Mississippi River. It is expected that 24 more water quality control problems will have developed by 2020. Dennis (1975) and Patrick and Gambrell (1976) have reported widespread occurrences of PCB's and heavy metals in surface waters and bottom sediments of the major U.S. drainage basins. Studies have shown that in heavily populated areas of the Upper Mississippi River water quality has deteriorated with increases in bacterial concentrations. Minnesota, Wisconsin, Illinois, Iowa and Missouri have recommended that water quality criteria be

established as early as 1953 for the interstate and intrastate waters of the Upper Mississippi River and its tributaries (U.S. Public Health Service 1953). These states have developed and implemented comprehensive programs for pollution abatement in cooperation under the enforcement of the Federal Water Pollution Control Act Amendments of 1972. Water quality of the UMR has been undertaken as part of a national assessment of anticipated environmental impacts of theoretically achieving or not achieving the requirements of the Clean Water Act (Water Resources Engineers 1975).

Recommendations: See Recommendations for 1. GREAT I, 2. GREAT II, and 3. GREAT III.

Literature Cited:

Dennis, D. S. 1975. Polychlorinated biphenyls in the surface waters and bottom sediments of the major drainage basins of the United States. Presented at EPA Conf. on PCB's, Chicago, Nov. 19-21, 183 pp.

Gakstatter, J. H. and R. L. Morris. 1970. Mississippi River water quality survey report at Burlington, Iowa. State Hygienic Laboratory Report 70-41. University of Iowa.

Larson, S. P., W. B. Mann, IV, T. D. Steel and R. H. Susag. 1976. Graphic and Analytical Methods for Assessment of Stream-Water Quality Mississippi River in the Minneapolis-St. Paul Metropolitan Area, Minnesota. Geological Survey, St. Paul, Minn. Water Resources Div. Metropolitan Waste Control Commission, St. Paul, MN. 63 pp.

Patrick, W. H., and R. P. Gambrell. 1976. The effect of pH and redox potential on heavy metal chemistry in sediment-water systems affecting toxic material bioavailability. Presented at World Dredging Conf on Env. Effects & Technology of Dredging. San Francisco. July 10-12, 1976. 579 pp.

U.S. Public Health Service. 1953. A Comprehensive Program for Water Pollution Control for the Mississippi-Wapsipinicon and Tributaries Rivers Basin Developed by the State Water Pollution Control Agencies, of Illinois, Iowa, Minnesota, and Wisconsin. Cincinnati, Ohio. Div. of Water Supply and Pollution Control. 50 pp.

Upper Mississippi River Comprehensive Basin Study. 1970. Volume IV. Appendix H: Water Supply and Quality Control. Coordinating Committee, Chicago, IL. 363 pp.

Water Resources Engineers, Inc. 1975. Water Quality Analysis Upper Mississippi River Basin. Walnut Creek, Calif. National Commission on Water Quality, Washington, D.C. 115 pp.

E. Waste Discharge Water Quality Impacts

1. Industrial

a. GREAT I

Information: Thirty-five references referring to industrial discharges in the GREAT I Region were compiled and reviewed (Table 58). All references pertained to industrial discharge surveys with 21 specifically relating to thermal effluent impacts, while the remaining dealt with either chemical effluents or spills. Most studies were conducted in Pool 1 near Northern States Power's Monticello and Prairie Island Nuclear Generating Stations. Biological investigations were conducted to assess the thermal impact on the aquatic environment before and after station operation. Other than Pool 1, limited information was available in Pools 3, 4 and 5. Six articles were of general nature and included the entire GREAT I Region.

Voids: Most articles dealt with the thermal aspect of industrial discharges with only limited information concerning other types of chemical discharges. No references were available on regulations, violations or standards of industrial effluents. Pools 7, 8 and 10 had no specific references on industrial effluents impacts.

Evaluation: The most comprehensive surveys on industrial discharges in the GREAT I Region were conducted for Northern States Power Co.'s Electrical Generating Stations (Northern States Power Co., 1972, 1973a, 1973b, 1974, 1977a, 1977b). Several studies by Eberley (1975), Hopwood (1974) and Lager (1876) showed that the abundant peaks, biomass and weight patterns of macroinvertebrates were similar before and after station operation. During nine years of extensive periphyton monitoring at Monticello Station no adverse environmental effects have been detected (Northern States Power Co. 1977a). Ott

(1973) reported that fish composition from 1970 to 1973 at Monticello Station showed no significant change. Hopwood (1974) noted, however, that some species of fish were attracted to thermal effluents. Other studies conducted by Dieterman (1875), Nemanick (1973) and Ranthum (1971) showed that thermal impacts were restricted only to areas of the station discharge. Limited information was available on other types of industrial discharges in the GREAT I Region. The Minnesota Pollution Control Agency (1975) reported PCB buildup in surface waters and bottom sediments due to increased industrial discharging. The PCB levels in fish varied with species and location (Minnesota-Wisconsin PCB Interagency Task Force 1975, 1976). Kleinert and Degurse (1972) reported all fish analyzed along the Wisconsin border of the Mississippi River contained some mercury, with highest concentrations occurring in fish collected below paper mills. Virnig (1971) reported that mercury levels in fish from the Trempeleau Bay area of Pool 6 were below the 0.5 ppm FDA Standard. The Minnesota Pollution Control Agency (1973) maintains files on all industrial spills in Minnesota's waterways. These files include material spilled, cleanup activities and immediate damage to wildlife and surrounding area.

Recommendations: Environmental impact studies should be conducted on industrial effluents, especially where information is not available. These studies should be performed prior to plant operation in order to obtain baseline reference information. It should be encouraged that whenever any aquatic study is conducted, all trophic levels be examined for possible environmental impacts.

Literature Cited:

Dieterman, S. 1975. A short-term impact study of the zooplankton population dynamics in Pool 3 of the Mississippi River near the Northern States Power Red Wing Nuclear Power Plant. M.S. Thesis, St. Mary's College, Winona, MN.

Eberley, L. W. 1975. Spawning activities of major fish species in the Monticello area of the Mississippi River. M.S. Thesis. St. Cloud State Univ., St. Cloud, MN. 80 pp.

Flynn, M. T. 1975. Primary production and chlorophyll a content of phytoplankton during 1973-1974 in Pool No. 3 of the Upper Mississippi River near Red Wing, Minnesota. B. A. Thesis. St. Mary's College, Winona, MN. 73 pp.

Hopwood, A. J. 1974. Thermal effects of nuclear power on the Mississippi River at Monticello, Minnesota. Water Resources Research Center, Univ. of Minnesota Graduate School. 131 pp.

Kleinert, S. J. and P. E. Degurse. 1972. Mercury levels in Wisconsin fish and wildlife. Wis Dept. Nat. Res. Tech. Bull. No. 52.

Lager, T. M. 1976. The effect of a thermal discharge on the macroinvertebrates in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud State University, St. Cloud, MN. 112 pp.

Matter, W. J. 1975. Invertebrate drift in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud State University, St. Cloud, MN. 80 pp.

Minnesota Pollution Control Agency. 1973. Spills Unit. Memoranda; reports on spills. Roseville, MN. (Comm.)

____________. 1975. *PCB Investigation of the Mississippi River and its tributaries water, bottom sediment and point sources.* 21 pp.

Minnesota-Wisconsin PCB Interagency Task Force. 1975. Preliminary report on the polychlorinated biphenyls in the Mississippi River and Lake Pepin. Minn. Poll. Cont. Agency and Wis. Dept. Nat. Res. joint pub. 13 pp.

Mischuk, M. W. 1976. Primary productivity in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud State University. St. Cloud, MN. 110 pp.

Nemanick, J. M. 1973. Recolonization of macroinvertebrates on artificial substrate samples in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud St. Univ., St. Cloud, MN. 106 pp.

Northern States Power Company. 1972. *Monticello Nuclear Generating Plant.* Unit 1. Mississippi River Flow and Temperature Data. Minneapolis, MN. 15 pp.

____________. 1973a. Monticello Nuclear Generating Plant. Unit 1. Environmental Monitoring and Ecological Studies Program. Annual Report 1972. Minneapolis, MN. 576 pp.

____________. 1973b. Prairie Island Nuclear Generating Plant. Units 1 and 2. Environmental Monitoring and Ecological Studies Program. Annual Report. 1972. Minneapolis, MN. 754 pp.

______________. 1974. Monticello Nuclear Generating plant. Unit 1. Semi-annual Operating Report No. 7, January - June 1974. Minneapolis, MN. 118 pp.

______________. 1977a. Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota, Vol. 1. 456 pp.

______________. 1977b. Annual Report for the Monticello Nuclear Generating Plant, Monticello, Minnesota. Environmental Monitoring and Ecological Studies Program. 131 pp.

Ott, J. D. 1973. Fluorescent dyemarking of Cyprinid minnows. (Family Cyprinidae) and other small fish for population studies in the Mississippi River near Monticello, Minnesota. M.S. Thesis. St. Cloud State Univ., St. Cloud, MN. 77 pp.

Ranthum, R. G. 1971. The effects of heated effluent from the Dairyland Power Plant at Genoa on Water Temperatures and Fish of the Mississippi River. Wis. Dept. Nat. Res. Div. Forest. Wildl. and Rec., Bur. Fish Manage., Manage. Rept. No. 48.

Virnig, T. T. 1971. Determination of mercury concentrations in rough fish from Pool 6 of Mississippi River. B.A. Thesis. St. Mary's College, Winona, MN. 31 pp.

b. GREAT II

Information: Fifty-six references referring to industrial discharges in the GREAT II Region were compiled and reviewed (Table 59). All references pertained to industrial discharge surveys with 49 specifically relating to thermal effluent impact, 6 concerning chemical effluents, and 1 on chemical spills. Most studies were conducted in Pool 14 near Commonwealth Edison's Quad-Cities Nuclear Station. Three articles were of general nature and included the entire GREAT II Region.

Voids: Most articles dealt with the thermal aspect of industrial discharges with only limited information concerning other types of discharges. No references were available on regulations, violations or standards of industrial effluents. Pools 11, 12, 16-18 and 20-22 had no specific references on industrial discharge impact.

Evaluation: The most comprehensive surveys on industrial discharges in the GREAT II Region were associated with power plant thermal effluents. Industrial BIO-TEST Laboratories, Inc. (1971, 1972a, 1972b, 1972c, 1973a, 1973b, 1974a, 1974b, 1975a and 1975b) and NALCO Environmental Sciences (1976a, 1976b, 1976c, 1977a, 1977b, 1977c and 1978) conducted extensive aquatic studies in the vicinity of Commonwealth Edison Co.'s Quad-Cities Station (Pool 14) during preoperational and operational periods. This data provided detailed information concerning the thermal impact on phytoplankton, periphyton, zooplankton, macroinvertebrates and fish populations. NALCO Environmental Sciences noted that a diffuser-type system of releasing cooling water had no adverse impact on biotic communities in the Mississippi River near the station. Latvaitis (1974) reported that fishes would pass through the slight temperature differential created by the heated effluents. Thermal-hydraulic model studies by Parr and

Sayre (1977) demonstrated that the diffuser-pipe system of releasing cooling water from Quad-Cities Station was in compliance with state and federal discharge standards. Environmental impact studies of other types of industrial discharges in the GREAT II Region have been limited. Fisher (1956) reported that oil, acid and mine waste discharges have affected the breeding and feeding grounds of fishes. His information was inadequate because no discussion was made of methodology utilized or type of data obtained. Kleinert (1975) reported that PCB levels in certain fish from various pools exceed FDA standards; however, no information was given to the type of industrial discharge tested. Kleinert (1975) also indicated that fallout may be contributing much greater amounts of PCB's in fish than industrial effluents.

Recommendation: Environmental impact studies should be conducted on industrial effluents, especially where information is not available. These studies should be performed prior to plant operation in order to obtain baseline reference information. It should be encouraged that whenever any aquatic study is conducted, all trophic levels be examined for possible environmental damage.

Literature Cited:

Fisher, H. J. 1956. Pollution and Missouri fishes. Missouri River. Mo. Conser. 17(12): 6-7.

Industrial BIO-TEST Laboratories, Inc. 1971. O. E. Fancher, ed., Preoperational environmental monitoring (thermal) of the Mississippi River near Quad-Cities Station (July 1970 through December 1970). Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1972a. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (April 1971 through December 1971). 3 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

__________. 1972b. M. P. Locke, ed., Determination of thermal effects in the Mississippi River near Quad-Cities Station (January 1972 through July 1972) 2 Vol. Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1972c. Determination of thermal effects in the Mississippi River near Quad-Cities Station (August-December 1971). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1973a. M. P. Locke and H. O. Eiler, eds., Determinations of the thermal effects in the Mississippi River near Quad-Cities Station (August 1972 through January 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1973b. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1973 through July 1973). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1974a. H. O. Eiler and J. J. Delfino, eds., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1973 through January 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1974b. R. P. Markel, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1974 through July 1974). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1975a. R. M. Gerhold, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (August 1974 through January 1975). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1975b. R. M. Gerhold, ed. Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC Report (February 1975 through July 1975). Prepared for Commonwealth Edison Co., Chicago, IL.

Kleinert, S. J. 1975. Sources of polychlorinated biphenyls in Wisconsin. Wis. Dept. Nat. Res. 124 pp.

Latvaitis, P. B. 1974. Preliminary fish tagging investigation in Pool 14 of the Mississippi River. Drum and Croaker, Volume 15 (74) No. 1.

NALCO Environmental Sciences. 1976a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1975 through January 1976). Prepared for Commonwealth Edison Co., Chicago, IL.

____________. 1976b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (August 1975 through January 1976).

____________. 1976c. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report (February 1976 through July 1976). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1977a. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station, NRC report, (August 1976 through January 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1977b. R. M. Gerhold, ed., Operational environmental monitoring in the Mississippi River near Quad-Cities Station (February 1976 through January 1977). Prepared for Commonwealth Edison Co., Chicago, IL.

______________. 1977c. Operational environmental monitoring in the Mississippi River near Quad-Cities Station (August 1977 through January 1978). Prepared for Commonwealth Edison Co., Chicago, IL.

Parr, A. D., and W. W. Sayre. 1977. Prototype and Model Studies of the Diffuser-Pipe System for Discharging Condenser Cooling Water at the Quad-Cities Nuclear Power Station. Iowa Inst. of Hydraulic Research, Iowa City. Iowa State Water Resources Research Inst., Ames. Commonwealth Edison Co., Chicago, IL. 266 pp.

c. GREAT III

Information: Three references referring to industrial discharges in the GREAT III Region were compiled and reviewed (Table 60). All references pertained to industrial discharge surveys, specifically relating to chemical effluent impact in the Lower Stretch or of the GREAT III region in general.

Voids: Data on industrial discharges in the GREAT III Region was limited, with no information concerning the impact of thermal effluents or chemical spills. No references were available on regulations, violations or standards of industrial effluents. Pools 24, 25 and 26 had no specific references on industrial discharge impact.

Evaluation: Limited environmental survey information was available on industrial discharges in the GREAT III Region. National Field Investigations Center (1970) reported industrial pollution in the St. Louis area was seriously affecting the water quality. Fisher (1956) noted that oil, acid and mine waste discharges were some of the polluting substances affecting the biotic communities. Missouri Department of Conservation (1970) conducted fish surveys to assess the palatability of fish in polluted waters. Several studies were also conducted by Union Electric Co. (1979a,b) to assess the environmental impact of thermal effluents on the Lower Stretch of the Upper Mississippi River.

Recommendations: Environmental impact studies should be conducted on industrial effluents, especially where information is not available. These studies should be performed prior to plant operation in order to obtain baseline reference information. It should be encouraged that whenever any aquatic study is conducted, all trophic levels be examined for possible environmental damage.

Literature Cited:

Fisher, H. J. 1956. Pollution and Missouri fishes. Missouri River. Mo. Conserv. 17(12): 6-7.

Missouri Department of Conservation. 1970. Palatability of three species of fish and aroma of water from sites on the Mississippi River. Columbia, MO. 6 pp.

National Field Investigations Center. 1970. Report on the effect of the St. Louis metropolitan area on water quality in the Mississippi River, December 1969. Cincinnati, OH. 79 pp.

Union Electric Company. 1979a. Rush Island Plant: Demonstration in support of alternate effluent limitation on the thermal discharge. Section 316(a) PL92-500. Submitted 4. Mo. Dept. Nat. Res. Div. Environ. Qual. St. Louis, MO.

______________. 1979b. Rush Island Plant: Evaluation of cooling water intake impacts on the Mississippi River. Section 316(a) PL92-500. Submitted c/o Mo. Dept. Nat. Res. Environ. Qual. St. Louis, MO.

d. Upper Mississippi River

Information: Thirty-five references referring to industrial discharges of the Upper Mississippi River not specific to any GREAT Region were compiled and reviewed (Table 60). All references pertained to industrial discharge surveys, with 21 specifically relating to thermal effluent and the remainder dealing with either chemical effluents or spills. Most of the information was directed towards the general condition of the Upper Mississippi River as impacted by industry. Some of the studies conducted were laboratory projects to determine the toxic effluents of thermal or chemical discharges.

Voids: Although there are 35 references on industrial discharges in the Upper Mississippi River, the majority of this information was directed towards the general condition of the river with no reference to specific pool or GREAT Regions.

Evaluation: Peterson and Jaske (1968, 1970) projected that the thermal capacity of the Upper Mississippi River Basin has adequate cooling capacity to accomodate forecasted power plant growth through 1990. With alternative cooling techniques for thermal discharges, the cooling capacity of the Mississippi River could be extended to year 2000 (Peterson and Jaske 1968, 1970, Gallagher 1974). This projection, however, did not consider what effect the additional heat would have on the biota in the Mississippi River. Studies (Brown 1974, Munson 1975, and Smith and Koenst 1974) have shown that slight temperature increments above ambient condition could affect feeding, spawning and/or behavioral activities of aquatic organisms. Alford (1974) identified other types of aquatic pollutants in the Mississippi River. He reported that effluents from paper mills, dye plants and mineral processing plants were

impacting the aquatic communities. In some cases, Alford (1974) provided evidence for enforcement of regulatory legislation. Fisher (1956) noted other industrial effluents such as oil, acid and mine wastes were also affecting the biota in the Mississippi River.

Literature Cited:

Alford, A. L. 1974. Environmental application of advanced instrumental analyses: Assistance projects FY 73. Environmental Protection Agency, Athens, GA. Southeast Environmental Research Lab. Office of Water Research and Technology, Washington, D.C.

Brown, H. W. 1974. Handbook of the effects of temperature on some North American fishes. Amer. Electric Power Service Corp. Canton, OH.

Gallagher, B. J. 1974. Energy production and thermal effects. Limnetics Inc. Report.

Munson, B. H. 1975. Behavioral reactions of juvenile rainbow trout (*Salmo gairdneri*) to a heated thermal plume. M.S. Thesis. Univ. of Minn. 33 pp.

Peterson, D. E. and R. T. Jaske. 1968. A Test Simulation of Potential Effects of Thermal Power Plants on Streams in the Upper Mississippi River Basin. Battelle-Northwest, Richland, WA. Pacific Northwest Lab. 81 pp..

______________. 1970. Potential Thermal Effects of an Expanding Power Industry-Upper Mississippi River Basin. Battelle-Northwest, Richland, WA. Pacific Northwest Lab. 95 pp.

Smith, L. L., Jr. and W. M. Koenst. 1974. Temperature Effects on Eggs and Fry of Percoid Fishes. USEPA National Water Quality Laboratory. 99 pp.

2. Municipal

a. GREAT I

For municipal waste discharge water quality impacts, the information for all three GREAT Regions have been combined.

Information: Thirty-six references referring to municipal discharges in the Upper Mississippi River were compiled and reviewed; all references pertained to municipal effluent surveys (Tables 61-63). Most studies were conducted near the Minneapolis-St. Paul sewage treatment facility (Pool 1) and at the Burlington and Ft. Madison, Iowa treatment facilities (Pool 19). Biological and chemical investigations were conducted to assess the impact of municipal effluents on the biotic communities. Limited information was also available for Pools 12 and 6 and the Lower Stretch. Eight articles were of a general nature and included either specific GREAT Regions or the entire Upper Mississippi River.

Voids: Although there are 36 references available relating to municipal effluent impact on the Upper Mississippi River, most studies have been conducted in only a few pools. No references were available on regulations, violations or standards of municipal effluents. Eighteen pools of the Upper Mississippi River had no specific references on municipal effluent impact (Tables 61-63).

Evaluation: Weibe (1928) and Skrypek (1969) conducted surveys in Pool 1 to assess the environmental impact of municipal effluents. These studies indicated that the Minneapolis-St. Paul sewage treatment facility was a factor in destroying aquatic life in the Upper Mississippi River. Skrypek (1969) reported that changes in fish composition in Pool 2 were related to the inefficient Twin-Cities waste treatment facilities. Rademacher (1964) noted that despite efforts of water pollution control, inefficient sewage waste

treatment has deteriorated water quality from Minneapolis-St. Paul downstream to Lake Pepin (Pool 4). Supportive data by Fremling (1964, 1970) have shown that mayfly populations, which are an excellent indicator of water quality, have been severely reduced by polluted conditions 30 miles below the Twin-Cities area. Dennison (1968) reported the Winona sewage plant was a major contributor of fecal coliform organisms in Pool 6. His data showed that some tributaries into Pool 6 were "dangerously contaminated" with fecal bacteria. Kosek (1968) demonstrated that the Winona sewage plant is only about 19% effective in terms of nitrogen removal. Increases in bacterial concentrations have also been reported in the Burlington and Ft. Madison, Iowa (Pool 19) area of the GREAT II Region (Gakstatter and Morris 1970, Iowa State Hygienic Laboratory 1969d). Gakstatter and Morris (1970) reported that biological effects of Burlington wastes were limited to a narrow area, approximately 0.5 miles below the outfall. His data showed that stonefly nymphs, which require high quality water, were absent from the polluted area. Helms (1970) reported that the distribution of slime bacteria extended 52 miles below the Dubuque sewage treatment plant. Iowa State Hygienic Laboratory (1969a,b,c and d) has indicated that deterioration in water quality in many areas of the GREAT II Region resulted from inefficient waste treatment facilities. Other findings by Bi-State Development Agency (1954) and Kittrell (1958) reported similar pollution problems from municipal effluents in the St. Louis area. Fremling (1964, 1970) reported that deterioraton in water quality severely reduced mayfly populations as far as 300 miles below St. Louis. Maran and Sulick (1977) demonstrated that advance waste treatment design could reduce suspended solids by 99% and BOD by 97%, resulting in increased water quality of the municipal effluent.

Recommendations: Environmental impact studies of municipal discharges should be conducted in all pools, especially where information is not available. Routine water quality parameters and methodologies should also be implemented so that water quality and biological data obtained are comparable among municipal outfalls. Best available technology (BAT) should be applied to existing waste treatment facilities which consistantly pollute the aquatic environment.

Literature Cited:

Bi-State Development Agency. 1954. Mississippi River water pollution investigation. St. Louis Metropolitan Area. 378 pp.

Dennison, S. G. 1968. Determination of fecal-coliform densities in Pool 6 of the Mississippi River for spring and summer seasons. B.A. Thesis, St. Mary's College, Winona, MN. 71 pp.

Fremling, C. R. 1964. Mayfly distribution indicates water quality on the Upper Mississippi River. Science 146(3648): 1164-1166.

______________. 1970. Mayfly distribution on a water quality index. Published by EPA - Water Quality Office. 44 pp.

Gakstatter, J. H. and R. L. Morris. 1970. Mississippi River water quality survey report at Burlington, Iowa. State Hygienic Laboratory Report 70-41. University of Iowa.

Helms, D. E. 1970. Slime distribution studies on the Mississippi River (progress report 2) Iowa Cons. Comm., Quart. Biol. Repts., 22(1): 45-48.

Iowa State Hygienic Laboratory. 1969a. Mississippi River water quality survey report - Davenport, Iowa - river miles 464.0 - 493.0 Report No. 70-7. Iowa City, IA. 48 pp.

______________. 1969b. Mississippi River water quality survey report - Muscatine, Iowa area - river miles 439.5 - 456.3. Submitted to the Iowa Water Pollution Control Commission. Iowa City, IA. Mimeo. 27 pp.

______________. 1969c. Mississippi River water quality survey report - Clinton, Iowa area - river miles 501.2 - 517.6. Submitted to the Iowa Water Pollution Control Commission. 32 pp.

______________. 1969d. Mississippi River water quality survey report - Fort Madison, Iowa area - river miles 377.3 - 383.3. Submitted to the Iowa Water Pollution Control Commission. Iowa City, IA. Mimeo. 29 pp.

Kittrell, F. W. 1958. Pollution of Interstate water of the Mississippi River in the St. Louis metropolitan area. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Prepared in cooperation with Missouri State Div. of Health, Illinois State Sanitary Water Board, and the Bi-State Development Agency of the Missouri-Illinois Metropolitan Area. 32 pp.

Kosek, S. R. 1968. A study of nitrogen content of Mississippi River Pool 6 and streams tributary to it. B.A. Thesis, St. Mary's College, Winona, MN. 23 pp.

Maran, E. and D. Sulick. 1977. Lake Alton. Water Sewage Works 124 (4):68.

Rademacher, J. M. 1964. Pollution of the waters of the Upper Mississippi River and its significant tributaries, Minneapolis - St. Paul Metropolitan Area, Minnesota-Wisconsin. Public Health Service, Chicago, Ill. Div. of Water Supply and Pollution Control. 95 pp.

Skrypek, J. L. 1969. Difference in the composition of the fish population in Pool 2 and other areas of the Mississippi River as related to the waste from the Twin City Metropolitan Area-1964. Minn. Dept. Nat. Res., Investigational Rept. No. 307.

Wiebe, A. H. 1928. Biological survey of the Upper Mississippi River, with special references to pollution. Bull. U.S. Bur. Fish. Bureau of Fisheries Document No. 1028, 43(1927):137-167. Washington, D.C.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

3. Agricultural

a. GREAT I

For agricultural waste discharge water quality impacts, the information for all three GREAT Regions will be combined.

Information: Sixty-four references referring to impact of agricultural land runoff on the Upper Mississippi River were compiled and reviewed; of these, 60 dealt with agricultural surveys, and only four references were specific to regulations (Tables 64-66). Most studies were conducted in the GREAT I Region of Pools 1-4. Biological and chemical investigations were conducted to assess the impact of agricultural pesticide runoff on the biotic communities. Limited information was also available in Pools 8 and 9. Forty-one references were of general nature and included either specific GREAT Regions or the entire Upper Mississippi River.

Voids: Although there were 60 references available relating to the impact of agricultural runoff on the Upper Mississippi River, most studies have been conducted in only a few pools. No references were available on violations or standards of agricultural runoffs. Fifteen pools of the Upper Mississippi River had no specific references pertaining to agricultural surveys.

Evaluation: Several investigators (Chambers and Yarbrough 1974; Johnson 1966; Kleinert et al. 1968; Scales and Yarbrough 1975; Walker 1964a, b; and Wauchope 1975) reported that the occurrences of agricultural pesticides were widely distributed throughout the Upper Mississippi River. Routine monitoring of pesticides by Johnson and Morris (1974) showed insecticides were being carried into the Mississippi River by soil erosion. Scales and Yarbrough (1975) and Morris and Johnson (1970a, b) reported that the extent of pesticide contamination such as DDT, Dieldrin and Aldrin was highly variable

and depended upon the areas sampled and the fish species analyzed. The Wisconsin Department of Natural Resources conducted surveys to determine the residual levels of pesticide contamination in fish from the Wisconsin waters of the Mississippi River (Degurse and Ruhland 1972). The waters selected were known to have relatively high pesticide contamination and very active sport and commercial fisheries. The Minnesota Department of Conservation also studied pesticide uptake in fishes at locations representative of forested and agricultural areas (Moyle and Skrypek 1969). Morris and Johnson (1972) reported that fish food habits may be directly associated with insecticide uptake. His data showed elevated Dieldrin levels in carp, catfish and buffalo but not in pan and game fish species such as bass, crappie, bluegill and walleye. Supportative data by Iowa State Hygienic Laboratory (1970) reported that predator game fish showed no evidence of pesticide concentrations approaching FDA action guidelines. Surveys of fish tissue analysis conducted by Morris and Johnson (1972) reported no pesticide uptake in areas of the river not draining row cropland. Moyle and Skrypek (1969) indicated that insecticide levels in fish from Minnesota waters have decreased since 1967 due to restricted use of pesticides. In-lab toxicity surveys by Kawatski and Schmulbach (1971a, b), Carlson (1966) and Walker (1964a) have provided extensive information on lethal and sublethal effects of pesticides on fish and crustacean assemblages.

Recommendations: Areas of active sport and commercial fishing which border agriculture lands should be surveyed for pesticide contamination. Pesticides which have the greatest impact on the aquatic community should be restricted. Improved soil conservation practices resulting in reduced siltation must be instigated on a broad scale to keep agricultural pesticides on the fields and out of streams.

Literature Cited:

Carlson, C. A. 1966. Effects of three organophosphorus insecticides on immature Hexagenia and Hydropsyche of the Upper Mississippi River. Trans. Am. Fish Soc. 95(1): 1-5.

Chambers, J. E. and J. D. Yarbrough. 1974. Parathion and methyl parathion toxicity to insecticide resistant and susceptible mosquitofish (Gambusia affinis). Bull. Environ. Contam. Toxicol. 11(4): 315-320.

Degurse, P. and J. Ruhland. 1972. Occurrence of chlorinated biphenyls in Mississippi River Fish. Fish Manage. Rept. No. 52 Wis. Dept. Nat. Res. Bur. Fish Manage. Madison, WI.

Iowa State Hygienic Laboratory. 1970. Pesticide levels in fish from Iowa streams. Rept. No. 71-23.

Johnson, L. G. 1966. Pesticide concentration levels in Iowa fish. Iowa Cons. Comm., Quart. Biol. Repts., 18(4): 19-23.

Johnson, L. G. and R. L. Morris. 1974. Chlorinated insecticide residues in the eggs of some freshwater fish. Bull. Environ. Contam. Toxicol. 11(6): 503-510.

Kawatski, J. A. and J. C. Schmulbach. 1971a. Accumulation of insecticide in freshwater ostracods exposed continuously to sublethal concentrations of aldrin or dieldrin. Trans. Am. Fish. Soc. 100(1): 565-568.

____________. 1971b. Toxicities of aldrin and dieldrin to the freshwater ostracod Chlamydotheca arcuta. J. Econ. Entomol. 64: 1082-1085.

Kleinert, S. J., P. E. Degurse and T. L. Wirth. 1968. Occurrence and significance of DDT and dieldrin residues in Wisconsin fish. Wis. Dept. Nat. Res., Tech. Bull. No. 41.

Morris, R. L. and L. G. Johnson. 1970a. Pesticide levels in fish and bottom silt from Iowa streams. Iowa State Hygienic Lab. Rept. No. 71-10. Iowa City, IA.

____________. 1970b. Pesticide levels in fish from Iowa streams. Iowa State Hygienic Lab. Rept. No. 71-23. Iowa City, IA. 6 pp.

____________. 1972. Dieldrin levels in fish from Iowa streams. Pest. Monitoring Jour. 5(1): 12-16.

Moyle, J. B. and J. L. Skrypek. 1969. Levels of DDT, DDE and Aldrin in muscle and brain tissue of some Minnesota fishes, 1962-1967. Minn. Dept. Nat. Res. Spec. Publ. No. 59.

Scales, E. H. and J. D. Yarbrough. 1975. Endrin uptake in Insecticide-resistant and susceptible mosquitofish (Gambusia affinis). J. Agric. Food Chem., Nov-Dec. 1975, 23(6): 1076 (4).

Walker, C. R. 1964a. *Toxicological effects of herbicides on the fish environment.* Water and Sewage Works, 3(3) (Part 1): 113-116.

Walker, C. R. 1964b. Toxicological effects of herbicides on the fish environment. Water and Sewage Works, 3(4) (Part 2): 173-175.

Wauchope, R. D. 1975. Fixation of Arsenical Herbicides, Phosphates, and Arsenate in Alluvial Soils. J. Environ. Qual., 4(3): 355.

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

4. Recreational

a. GREAT I

For recreational waste discharge water quality impacts, the information for all three GREAT Regions has been combined.

Information: Six references referring to recreational waste discharges into rivers or lakes were compiled and reviewed (Tables 67-69). All references were on non-Upper Mississippi River systems, of which four references dealt with recreational waste surveys and two references were specific to regulations. Most of the information dealt with storage and treatment of watercraft wastes.

Voids: No information was available on recreational waste discharges into the Upper Mississippi River. No biological or chemical surveys were conducted to assess the immediate impact of recreational waste discharges on the aquatic environment. Information on violations or standards of recreational waste discharges was not available.

Evaluation: The U.S. Federal Water Pollution Control Administration (USFWPCA) (1967) reported the main causes of watercraft pollution are from discharges of sewage and dunnage, occasional chemical and oil spills and related activities such as servicing and cleaning equipment. The main problem areas noted by USFWPCA (1967) were docks and marinas. The National Sanitation Foundation (1966) recommended criteria be established for evaluating devices that treat watercraft wastes in accordance with standard effluent criteria. Guidelines provided by New England Interstate Water Pollution Commission (1973) for the installation of pollution control devices to store and dispose of watercraft wastes could be applicable to other states. Clark (1967) listed several methods for collection and treatment for boat and moorage wastewaters, as well

as the approximate installation costs. Stokes (1971) described in detail a method of overcoming law enforcement and pollution problems by eliminating overboard discharge in restricted waters.

Recommendations: Limited biological and chemical investigations should be conducted to assess the impact of recreational waste discharges on the aquatic environment of the Upper Mississippi River. These studies should be conducted in highly used recreational areas and in docks and marinas. Overboard discharge should be eliminated in fish spawning areas and in active sport and commercial fishing areas.

Literature Cited:

Clark, B. D. 1967. Houseboat wastes: methods for collection and treatment. U.S. Federal Water Pollution Control Administration. Northwest Region, Pacific Northwest Water Laboratory, Report, Corvallis, OR. 91 pp. (Tech. Rept.)

National Sanitation Foundation. 1966. National Conference on Watercraft Waste Disposal. Ann Arbor, Michigan, May 31-June 1, 1966. Ann Arbor. 116 pp. (Conf. Proc.)

New England Interstate Water Pollution Control Commission, Technical Advisory Board. 1973. Uniform guidelines for the control of wastes and harmful effects attributable to watercraft and floating structures on inland fresh waters. New England Interstate Water Pollution Control Commission. Technical Report TR-18. Boston, MA. 19 pp. (Tech. Rept.)

Stokes, J. H. 1971. Pollution of the world's harbors, docks, and inland waterways, with particular reference to ships. Marine Technololgy Society. Journal (1): 13-21. (Period. Art.)

U.S. Federal Water Pollution Control Administration. 1967. Pollution of navigable waters by the operation of watercraft in the Missouri Basin Region. Kansas City, MO. 54 pp. (Tech. Rept.)

b. GREAT II

See a. GREAT I.

c. GREAT III

See a. GREAT I.

F. Sedimentation/Erosion

1. GREAT I

For the topic of sedimentation/erosion, the information for all three GREAT Regions are combined.

Information: Sixty-one references referring to sedimentation/erosion in the Upper Mississippi River were compiled and reviewed (Tables 70-72). Most sedimentation/erosion references specifically pertained to upland areas, stream bank backwaters as well as bed degredation. The Lower Stretch and Pools 1, 9 and 20 were referred to most often, however, information was available on several other pools. Thirty-one references were of general sedimentation information which pertained to specific pools and GREAT Regions, the entire Upper Mississippi River, and non-Upper Mississippi River.

Voids: Although there were 61 references referring to sedimentation/erosion, only limited information was available on the individual topics of upland, stream bank, backwaters and bed degredation. Information on upland and stream bank sedimentation/erosion and sedimentation rates for specific GREAT Regions was not available. Thirteen pools of the Upper Mississippi River had no specific references on sedimentation/erosion.

Evaluation: Many investigators (Claflin 1976, Jordan 1968, Ritchie and McHenry 1977, Stall 1972) reported the problems with transportation and deposition of sediment in the Upper Mississippi River. Studies by Fremling et al. (1976) identified areas of degredation in the UMR backwater system. He reported the degredation phenomenon of backwaters was not limited to any one area. Sedimentation surveys by McHenry et al. (1977) reported that upper Lake Pepin (Pool 4) is threatened with conversion to a marsh.

Recommendations: Upstream conservation practices such as planting of trees, pasture renovation, grassed waterways and terraces, and contoured and strip farming with the use of more hay would control soil erosion of stream bank and upland areas. Downstream flood control measures should complement upstream conservation practices. Environmental impact studies, especially mussel and benthic macroinvertebrate surveys, should be conducted prior to any activities to predict what man-induced effects could have on the river biota.

Literature Cited:

Claflin, T. O. 1976. Lake Onalaska rehabilitation feasibility assessment report on navigation Pool No. 7, Upper Mississippi River. Wis. Dept. Nat. Res.

Fremling, C. R., D. N. Nielsen, D. R. McConville and R. N. Vose. 1976. Aquatic Plants IN: The Weaver Bottoms: a field model for the rehabilitation of backwater areas of the Upper Mississippi River by modification of standard channel maintenance practices. Final report to the U.S. Army Corps of Engineers, St. Paul District. Contracts DACW37-75-C-0193 and DACW37-75-0194. 52 pp.

Jordan, P. R. 1968. Summary and analysis of sediment records in relation to St. Louis harbor sedimentation problem. Open File Rept. U.S. Geol. Sur., Water Resour. Div., 28 pp.

McHenry, J. R., J. C. Ritchie and C. M. Cooper. 1977. Recent sedimentation rates in Lake Pepin. Pap. Pres. at Miss. Riv. Res. Consortium Ann. Mtg. Winona, MN.

Ritchie, J. C., and J. R. McHenry. 1977. Recent sedimentation rates in Pool 9 of the Upper Mississippi River. Pap. pres. at Upper Mississippi Riv. Res. Consortium Ann. Mtg., June 8-10.

Stall, J. B. 1972. Effects of sediment on water quality. J. of Env. Quality, 1(14): 353-361.

2) GREAT II

See 1) GREAT I.

3) GREAT III

See 1) GREAT I.

4.0 Task C

The main objective of Task C is to establish a prioritized list of issues to be addressed and to develop three critical path schedules for completing the studies to fill the data voids identified in Tasks A and B. The corresponding tables to Task C are presented in Appendix B. Detailed definitions of the ten activities determined to occur on rivers (in the title of each table) and the physical/chemical alterations (across the top of each table) follow.

Type of Activity

Channel construction and maintenance - Activities which include nine-foot channel and/or otherwise navigation channel construction and maintenance. Includes widening, deepening, dredging, disposal of dredged material, and controlled water level fluctuations of existing main channels. Does not include side channels or channels for harbor construction.

Harbor, levee and breakwall construction and maintenance - Shoreline or side channel activities.

Corridor construction and maintenance - Includes pipelines, transmission lines, bridges, etc. and assumes that a corridor crosses all types of habitats, i.e., main channel, side channel, backwater.

Wingdam construction and maintenance - Structure which alters flow and velocity of the river.

Encroachment - Land moving onto/into water habitats, and flooding.

Mitigation - Actions taken to lessen environmental impacts from either man-induced or natural causes.

Point source intakes and discharges - Withdrawal of water from, or discharge of an effluent into a water body at a localized point.

Non point source discharges - Precipitation runoff reaching a water body from surrounding land masses, municipalities, or industrial areas.

Commerical navigation - Navigation for commerical purposes, i.e., barge traffic, or shipping.

Recreational navigation - Navigation for recreational purposes, i.e., water sports, pleasure boating, or recreational fishing.

Physical/Chemical Alterations (Potential Direct Impacts Only)

Sedimentation and resuspension - The specific settling of suspended material, i.e., silt, clay, etc., that was in the water due to currents or navigation, or any activity which disrupts the natural bottom.

Physical removal and disruptions - The physical removal or displacement of a habitat, e.g., taking a bottom grab with a dredge and depositing it in another place.

Burial - The actual burial of a habitat due to dumping of dredged spoils.

Desiccation - The drying-up of an aquatic habitat.

Innudation - The flooding of a terrestrial habitat.

Velocity/Flow - Changes in current velocity or the natural flow patterns of a river as a result of man's actions.

Turbidity - Disturbance of sediment and organic materials causing a darkening or obscuring of otherwise clear waters.

Toxic substances - The introduction of toxic substances to the water by man's activities.

Oxygen related - Changes in dissolved oxygen levels in the water as a result of man's activities.

Nutrient related - Changes in nutrient concentrations in the water caused by man's activities.

pH related - Changes in the alkalinity and acidity of the water caused by man's activities.

The list of issues to be addressed, i.e., studies to be conducted to fill data voids, were prioritized according to the following rationale and assumptions. The absence of data dealing with State or Federally listed threatened or endangered species was considered to be of greatest concern and was given highest priority. Within the threatened or endangered species category, highest priority was placed on two groups of aquatic organisms (fish and mussels), followed by mammals, birds, reptiles, amphibians, snails, macrophytes, and terrestrial vegetation. Aquatic or semi-aquatic organisms were generally given higher priority because of a greater likelihood of

impact from a river activity. Mammals and birds were an exception to this scheme and were given higher priority than reptiles, amphibians, snails, macrophytes, and terrestrial vegetation because of greater public concern and general interest for these two groups of organisms.

Lack of data on submergent characteristics was given next highest priority since the indigenous communities are directly dependent on submergent characteristics.

Data voids for groups of flora and fauna listed as "Indigenous Communities," excluding threatened or endangered species, were prioritized in accordance with their relative importance from a commercial, recreational, or general interest point of view, as well as the likelihood of impact from a river activity. For example, the relative importance of fish versus birds from a general interest point of view may be equal; however, fish are more likely to be impacted by a river activity than are birds, so data voids for fish were given higher priority. On the other hand, even though plankton are more likely to be impacted by a river activity than are mammals, the latter were considered to be of higher priority because of their greater importance from a commerical and general interest point of view, and the greater potential for impact on the overall community.

The above method of prioritization was used in Task C of this study; however, it is recognized that this is only one method of potentially several methods of prioritizing data voids.

The following pages present the prioritized list of issues to be addressed, the critical path schedules, and the two summary tables of data availability.

Prioritized List of Issues to be Addressed

1. Study of the threatened and endangered fish and mussels occurring in the Upper Mississippi River.

2. Study of the threatened and endangered mammals, amphibians, and reptiles occurring along the Upper Mississippi River.

3. Study of the submergent characteristics of the Upper Mississippi River.

4. Study of the impacts of channel maintenance and construction on fish eggs and larvae, juvenile fish, and adult feeding habits, spawning and reproduction, and age and growth. Most data lacking in the GREAT III area.

5. Study of the impacts of commerical and recreational navigation on fish eggs and larvae, juvenile fish, and adult feeding habits, spawning and reproduction and age and growth. Most data lacking in GREAT II area.

6. Study of the impacts of harbor, breakwall, levee, and/or wingdam maintenance and construction on fish eggs and larvae, juvenile fish, and adult feeding habits, spawning and reproduction and age and growth. Most data lacking in GREAT III area.

7. Study of the impacts of corridor maintenance and construction on fish eggs and larvae, juvenile fish, and adult feeding habits, spawning and reproduction and age and growth. Most data lacking in GREAT III area.

8. Study of the impacts of encroachment and flooding on fish eggs and larvae, juvenile fish, and adult feeding habits, spawning and reproduction and age and growth. Most data lacking in GREAT III area.

9. Study of the impacts of non point source discharges on fish eggs and larvae, juvenile fish, and adult feeding habits, spawning and reproduction and age and growth. Most data lacking in GREAT I area.

10. Study of the impacts of commerical and recreational navigation on mussels. Most data lacking in the GREAT II area.

11. Study of the impacts of harbor, levee, breakwall, wingdam, and/or channel maintenance and construction on mussels. Most data lacking in the Middle River.

12. Study of the impacts of encroachment and flooding on mussels. Most data lacking in the GREAT II area.

13. Study of the impacts of point source discharges and intakes on mussels. Most data lacking in the Middle River.

14. Study of the impacts of corridor maintenance and construction on mussels. Most data lacking in the GREAT II area.

15. Study of the impacts of non point source discharges on mussels. Most data lacking in GREAT I area.

16. Study of the impacts of harbor, levee, breakwall, and/or wingdam maintenance and construction on waterfowl, raptors, and other birds. Most data lacking in the Middle River.

17. Study of the impacts of channel and corridor maintenance and construction on waterfowl, raptors, and other birds. Most data lacking in the GREAT II area.

18. Study of the impacts of encroachment and flooding on waterfowl, raptors, and other birds. Most data lacking in the GREAT II area.

19. Study of the impacts of point source discharges and intakes on waterfowl, raptors, and other birds. Most data lacking in the GREAT II area.

20. Study of the impacts of non point source discharges on waterfowl, raptors, and other birds. Most data lacking in the GREAT II area.

21. Study of the impacts of commercial and recreational navigation on waterfowl, raptors, and other birds. Most data lacking in the GREAT II area.

22. Study of the impacts of harbor, levee, breakwall, and/or wingdam maintenance and construction on mammals, amphibians, and reptiles. Most data lacking in the GREAT II area.

23. Study of the impacts of channel and corridor maintenance and construction on mammals, amphibians, and reptiles. Most data lacking in the GREAT II area.

24. Study of the impacts of point source intakes and discharges on mammals, amphibians, and reptiles. Most data lacking in the GREAT I area.

25. Study of the impacts of non point source discharges on mammals, amphibians, and reptiles. Most data lacking in the GREAT I area.

26. Study of the impacts of commercial and recreational navigation on mammals, amphibians, and reptiles. Most data lacking in the GREAT II area.

27. Study of the impacts of commercial and recreational navigation on benthos, macrophytes, periphyton, phytoplankton, and zooplankton. Most data lacking in the GREAT II area.

28. Study of the impacts of point source intakes and discharges on benthos, macrophytes, periphyton, phytoplankton, and zooplankton. Most data lacking in the Middle River.

29. Study of the impacts of non point source discharges on benthos, macrophytes, periphyton, phytoplankton, and zooplankton. Most data lacking in the GREAT II area.

30. Study of the impacts of channel, corridor, harbor, levee, breakwall, and/or wingdam maintenance and construction on benthos, macrophytes, periphyton, phytoplankton, and zooplankton. Most data lacking in the GREAT III area.

31. Study of the impacts of encroachment and flooding on benthos, macrophytes, periphyton, phytoplankton, and zooplankton. Most data lacking in the GREAT III area.

32. Study of the threatened and endangered snails along the Upper Mississippi River.

33. Study of the threatened and endangered macrophytes in the GREAT I area.

34. Study of the threatened and endangered terrestrial flora along the Upper Mississippi River.

35. Study of the impacts of channel, corridor, harbor, levee, breakwall, and/or wingdam maintenance and construction on terrestrial flora. Most data lacking in the GREAT II area.

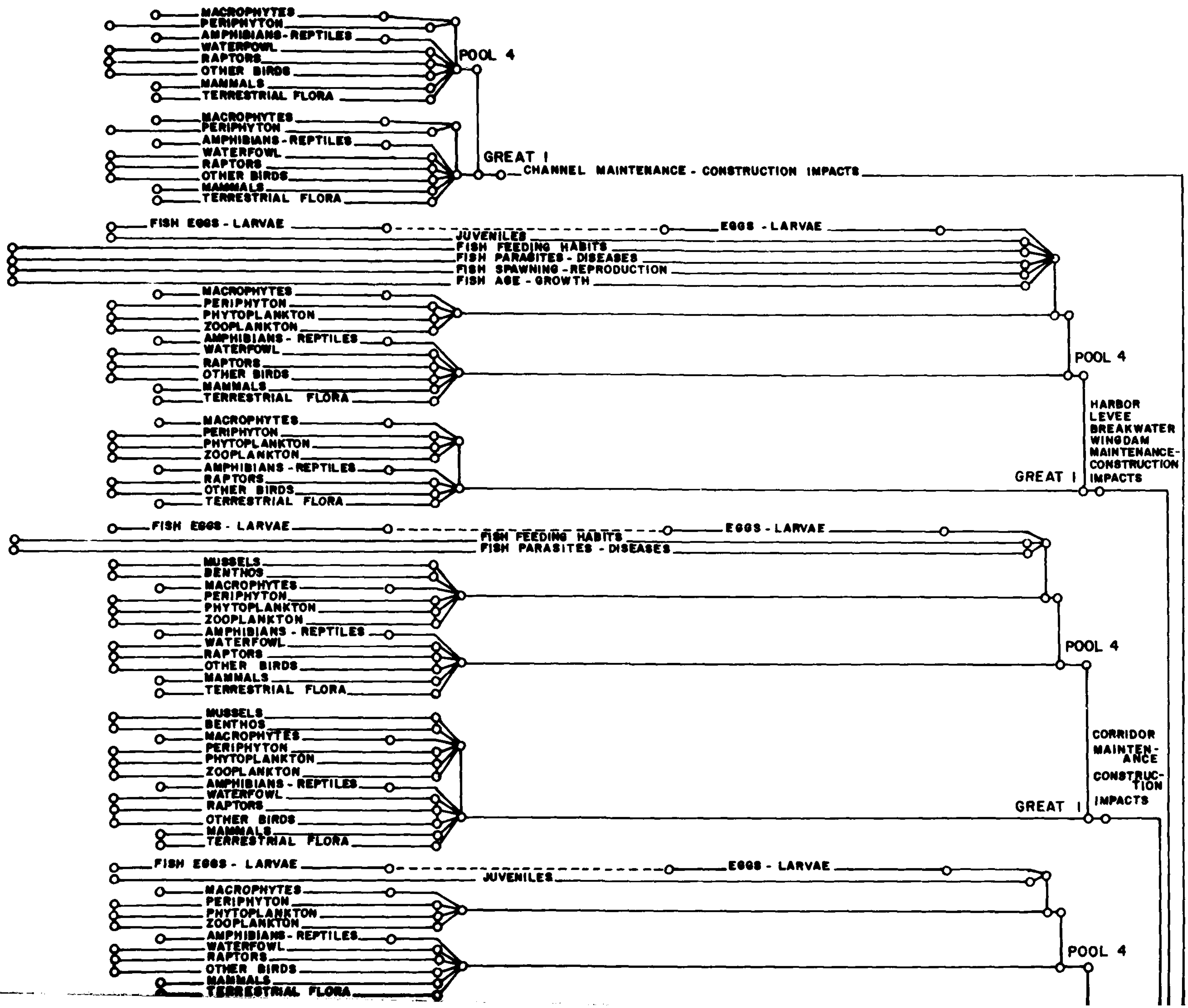
36. Study of the impacts of encroachment and flooding of terrestrial flora. Most data lacking in the GREAT II area.

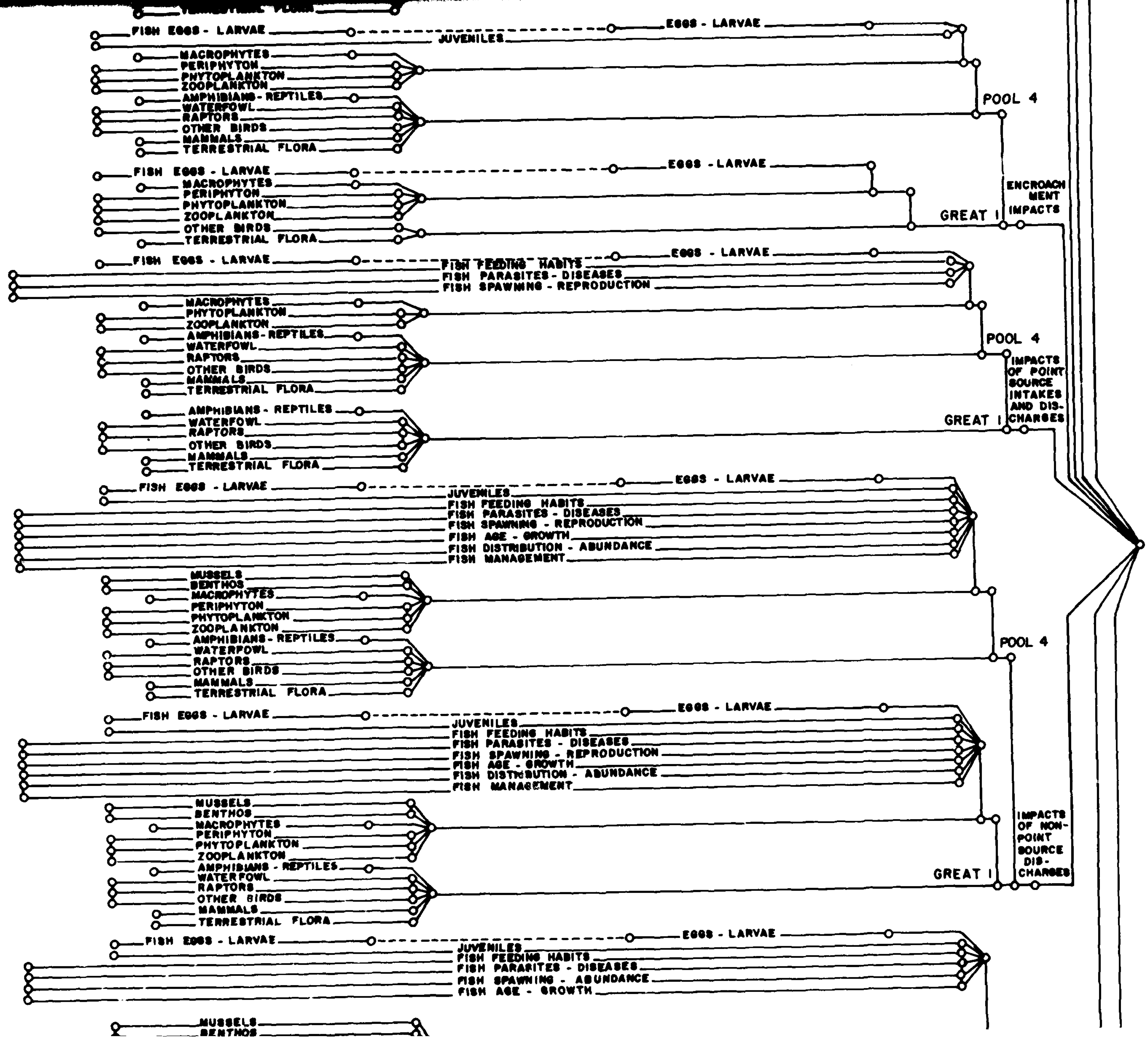
37. Study of the impacts of point source intakes and discharges on terrestrial flora. Most data lacking in the GREAT II area.

38. Study of the impacts of non point source discharges on terrestrial flora. Most data lacking in the GREAT II area.

39. Study of the impacts of commerical and recreational navigation on terrestrial flora. Most data lacking in the GREAT II area.

CRITICAL PATH SCHEDULE - GREAT I AREA STUDIES



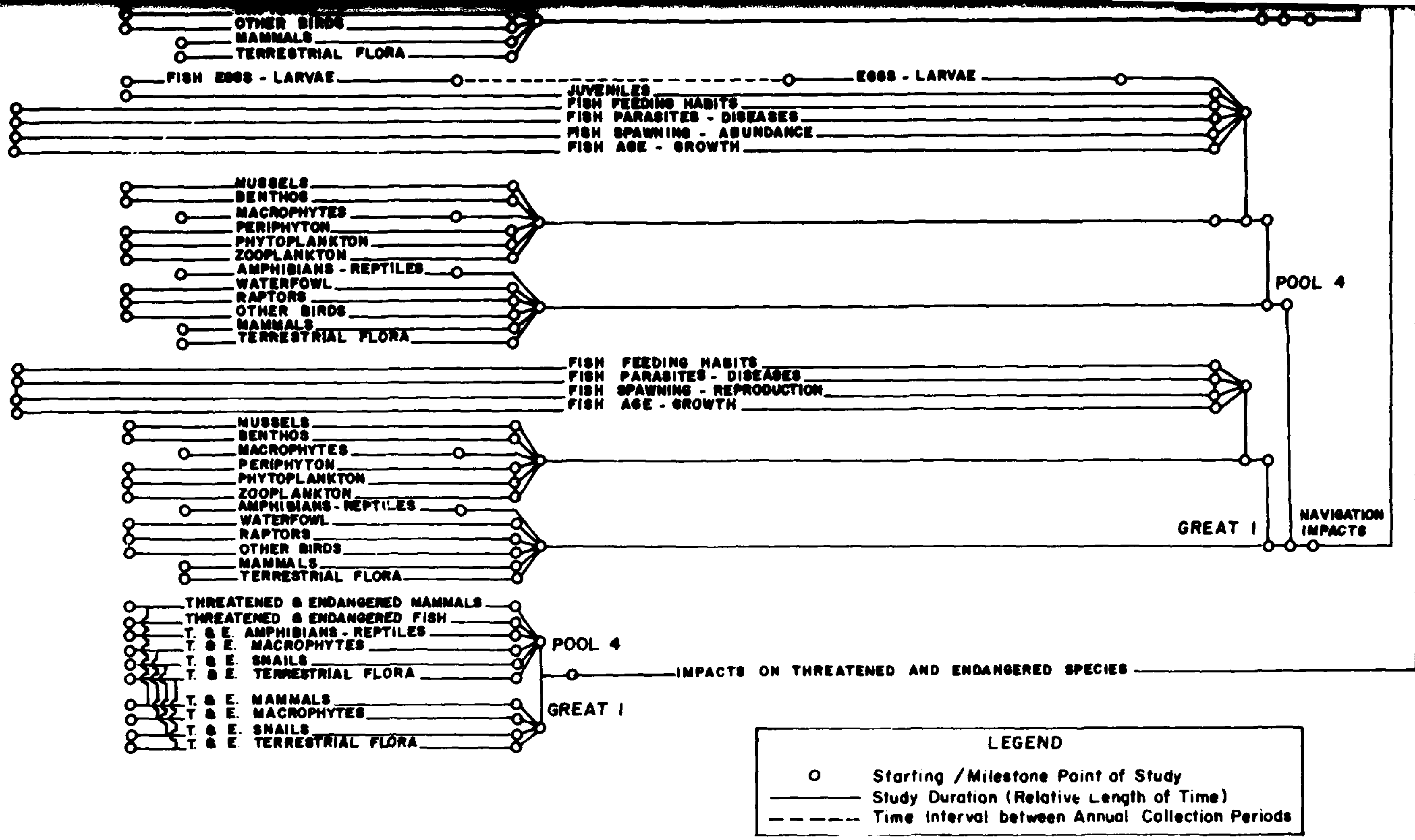

FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 4
FISH EGGS - LARVAE
EGGS - LARVAE
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
OTHER BIRDS
TERRESTRIAL FLORA
GREAT I
ENCROACH MENT IMPACTS
FISH EGGS - LARVAE
EGGS - LARVAE
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
MACROPHYTES
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 4
IMPACTS OF POINT SOURCE INTAKES AND DIS- CHARGES
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT I
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 4
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT I
IMPACTS OF NON- POINT SOURCE DIS- CHARGES
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - ABUNDANCE
FISH AGE - GROWTH
MUSSELS
BENTHOS

2

AD-A096 480 HAZLETON ENVIRONMENTAL SCIENCES CORP NORTHBROOK IL F/G 6/6
GREAT RIVER ENVIRONMENTAL ACTION TEAM (GREAT II). LITERATURE RE--ETC(U)
DEC 80 DACW25-79-C-0066
UNCLASSIFIED ES-9057 NL

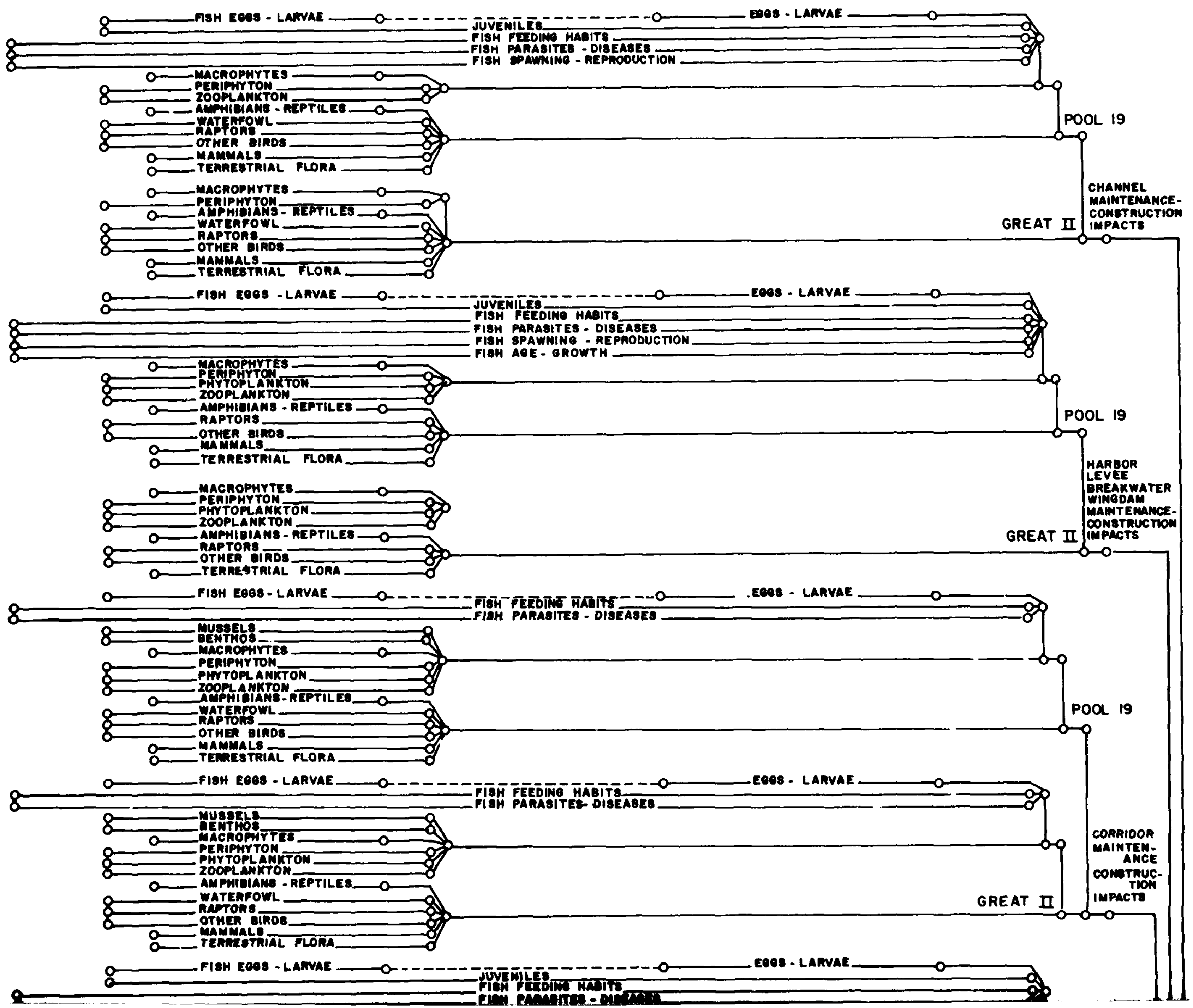
5 OF 6

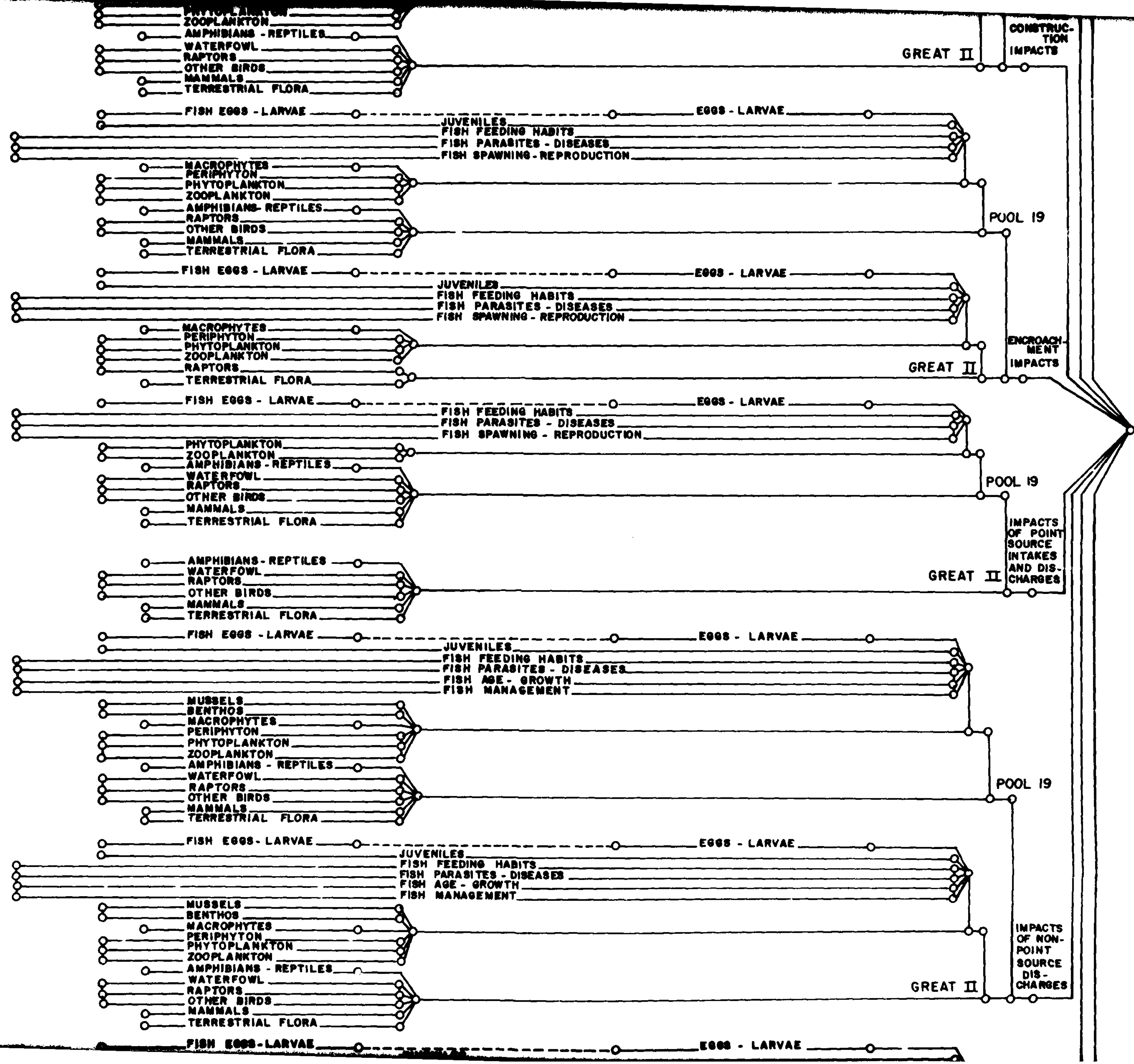
AD A
096480


OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - ABUNDANCE
FISH AGE - GROWTH
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 4
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT I
NAVIGATION IMPACTS
THREATENED & ENDANGERED MAMMALS
THREATENED & ENDANGERED FISH
T. & E. AMPHIBIANS - REPTILES
T. & E. MACROPHYTES
T. & E. SNAILS
T. & E. TERRESTRIAL FLORA
POOL 4
T. & E. MAMMALS
T. & E. MACROPHYTES
T. & E. SNAILS
T. & E. TERRESTRIAL FLORA
GREAT I
IMPACTS ON THREATENED AND ENDANGERED SPECIES
LEGEND
Starting / Milestone Point of Study
Study Duration (Relative Length of Time)
Time Interval between Annual Collection Periods

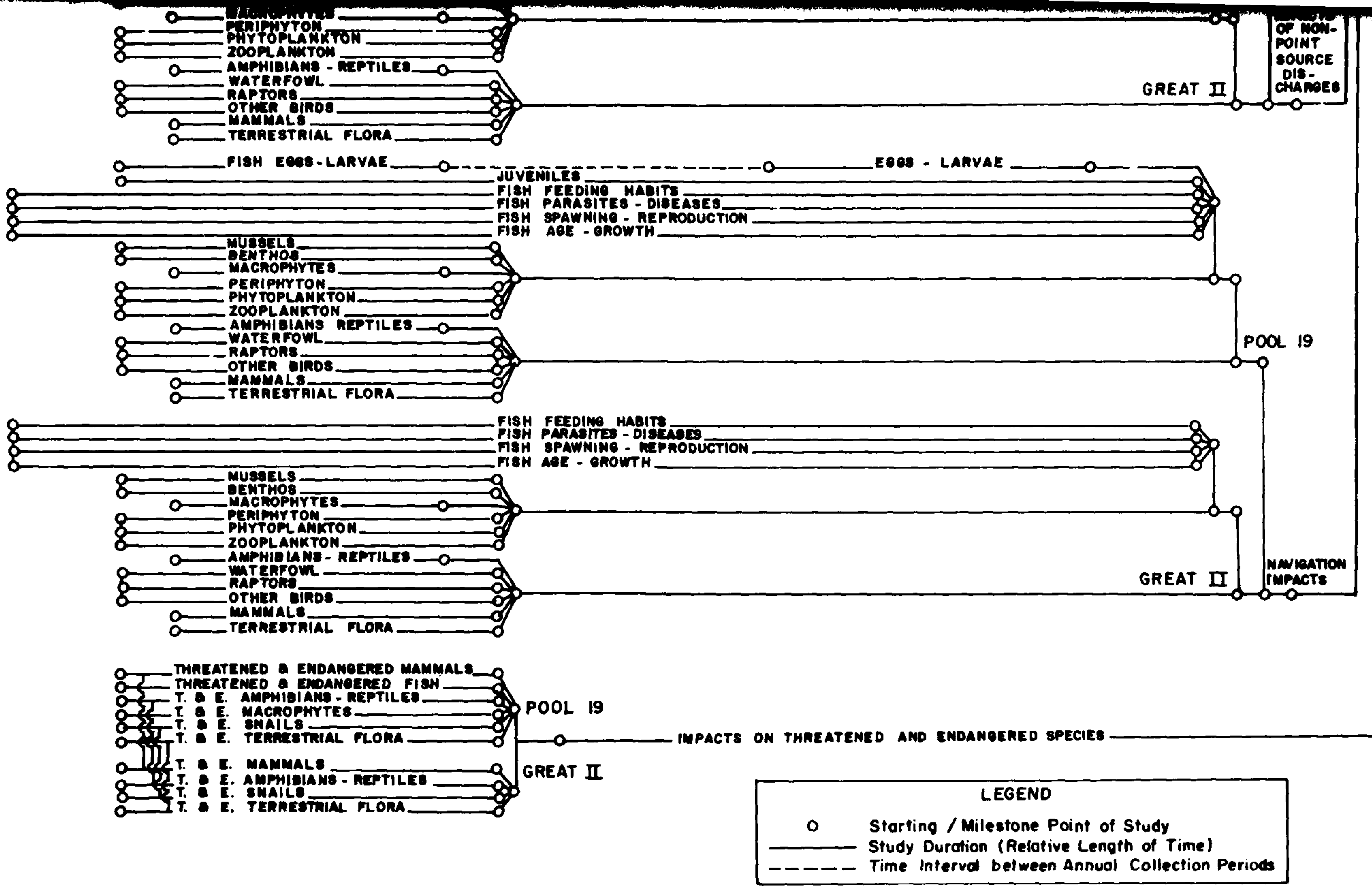
3

CRITICAL PATH SCHEDULE - GREAT II AREA STUDIES





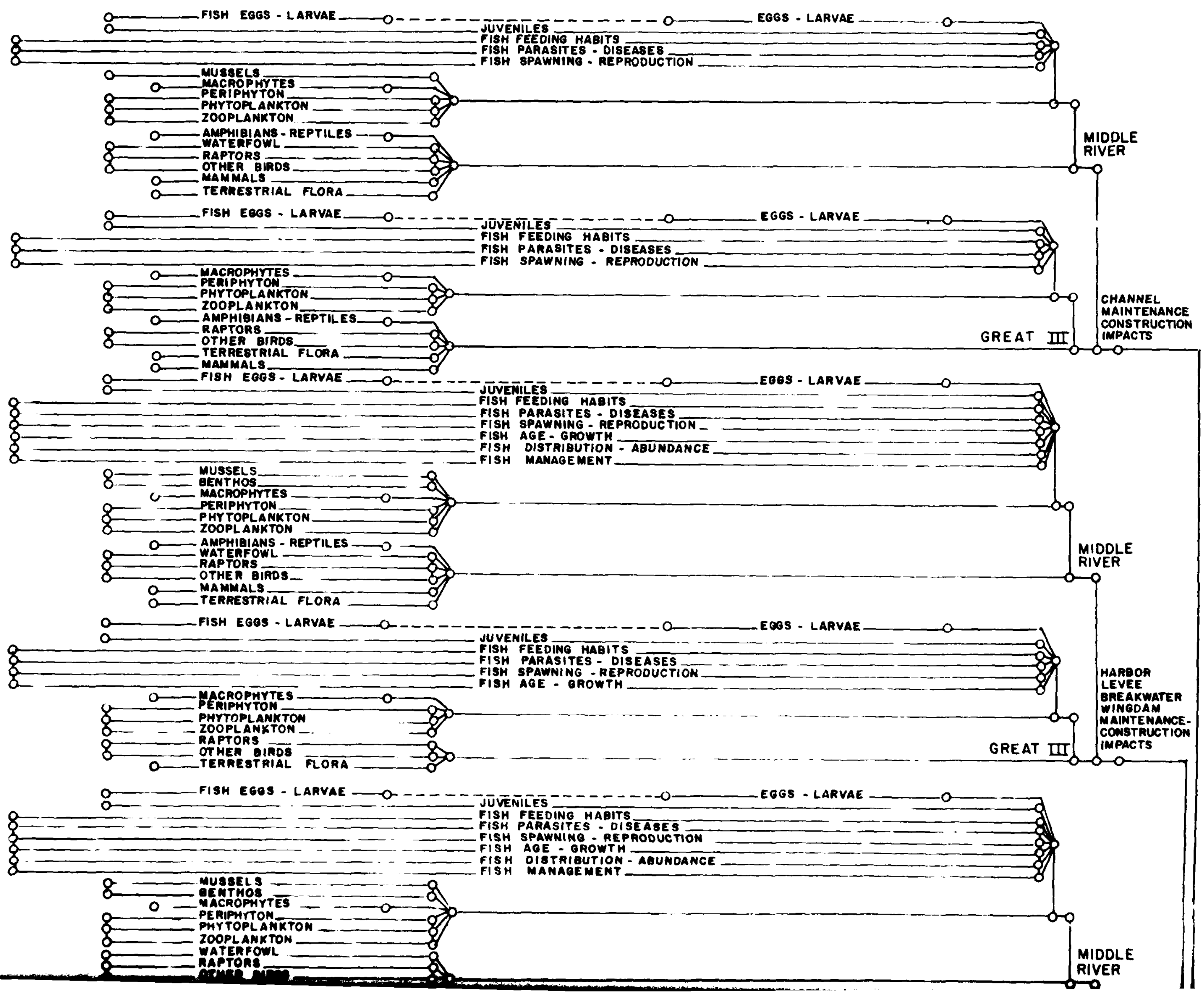
CONSTRUCTION IMPACTS
GREAT II
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 19
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
ENCROACHMENT IMPACTS
GREAT II
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
RAPTORS
TERRESTRIAL FLORA
POOL 19
FISH EGGS - LARVAE
EGGS - LARVAE
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
IMPACTS OF POINT SOURCE INTAKES AND DISCHARGES
GREAT II
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 19
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH AGE - GROWTH
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
IMPACTS OF NON-POINT SOURCE DISCHARGES
GREAT II
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH AGE - GROWTH
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
FISH EGGS - LARVAE
EGGS - LARVAE

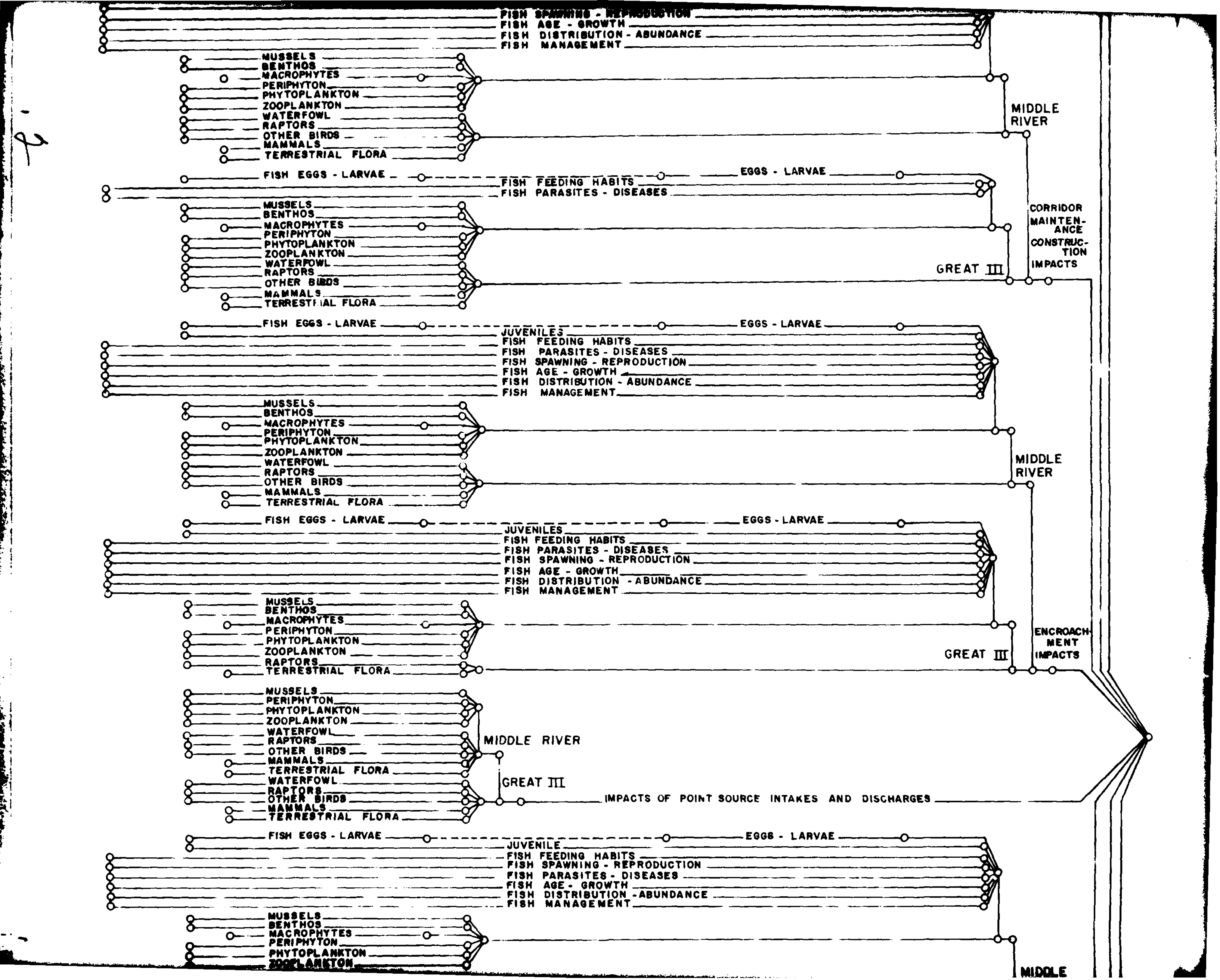


MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT II
OF NON-POINT SOURCE DIS-CHARGES
FISH EGGS-LARVAE
JUVENILES
EGGS - LARVAE
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
POOL 19
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT II
NAVIGATION IMPACTS
THREATENED & ENDANGERED MAMMALS
THREATENED & ENDANGERED FISH
T. & E. AMPHIBIANS - REPTILES
T. & E. MACROPHYTES
T. & E. SNAILS
T. & E. TERRESTRIAL FLORA
POOL 19
IMPACTS ON THREATENED AND ENDANGERED SPECIES
T. & E. MAMMALS
T. & E. AMPHIBIANS - REPTILES
T. & E. SNAILS
T. & E. TERRESTRIAL FLORA
GREAT II
LEGEND
Starting / Milestone Point of Study
Study Duration (Relative Length of Time)
Time Interval between Annual Collection Periods

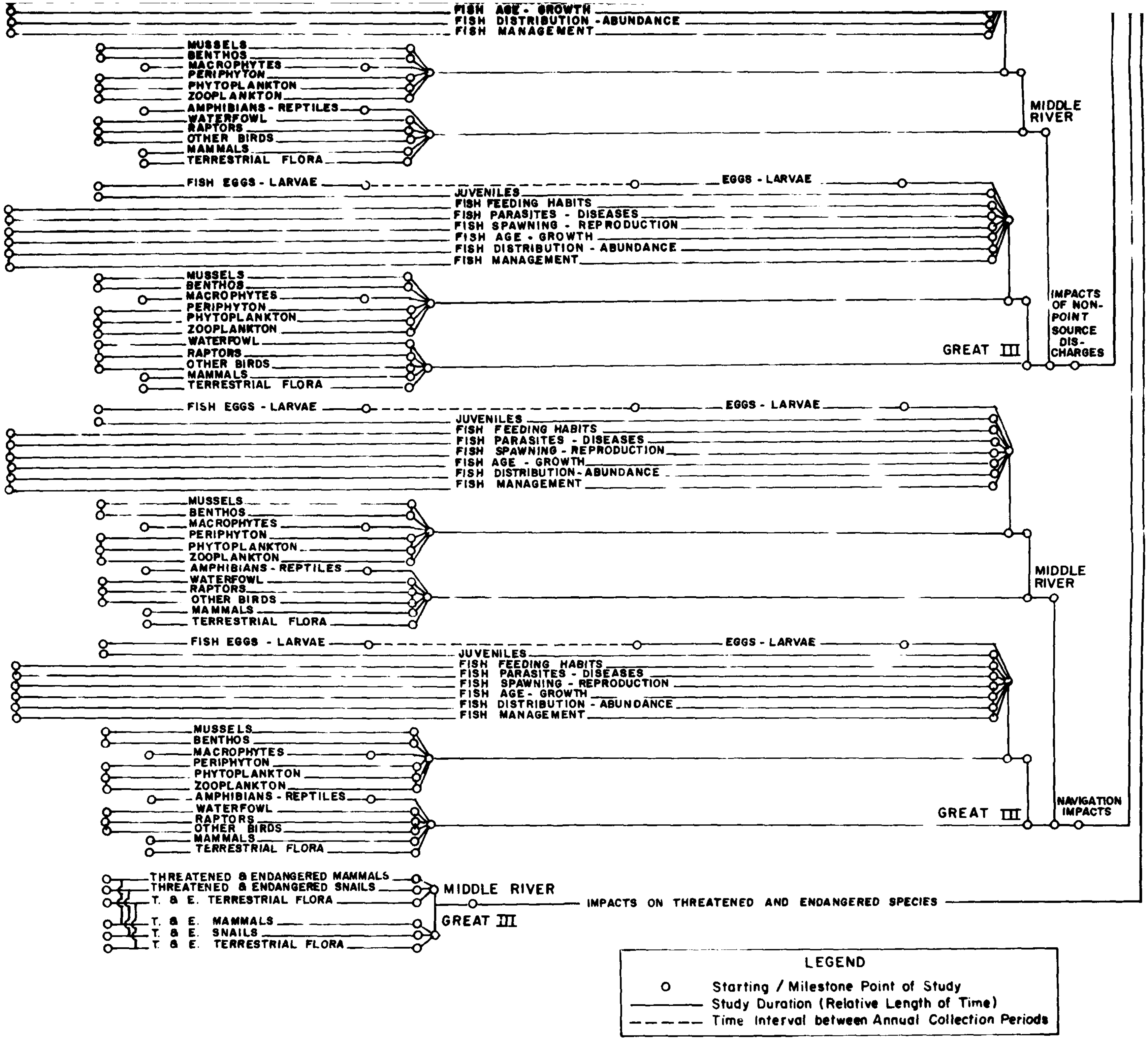
,3

CRITICAL PATH SCHEDULE - GREAT III AREA STUDIES




FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
MIDDLE RIVER
FISH EGGS - LARVAE
EGGS - LARVAE
FISH FEEDING HABITS
FISH PARASITES - DISEASES
CORRIDOR MAINTENANCE CONSTRUCTION IMPACTS
GREAT III
JUVENILES
ENCROACHMENT IMPACTS
IMPACTS OF POINT SOURCE INTAKES AND DISCHARGES
JUVENILE
MIDDLE

2


FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
MIDDLE RIVER
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT III
IMPACTS OF NON-POINT SOURCE DIS-CHARGES
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
MIDDLE RIVER
FISH EGGS - LARVAE
EGGS - LARVAE
JUVENILES
FISH FEEDING HABITS
FISH PARASITES - DISEASES
FISH SPAWNING - REPRODUCTION
FISH AGE - GROWTH
FISH DISTRIBUTION - ABUNDANCE
FISH MANAGEMENT
MUSSELS
BENTHOS
MACROPHYTES
PERIPHYTON
PHYTOPLANKTON
ZOOPLANKTON
AMPHIBIANS - REPTILES
WATERFOWL
RAPTORS
OTHER BIRDS
MAMMALS
TERRESTRIAL FLORA
GREAT III
NAVIGATION IMPACTS
THREATENED & ENDANGERED MAMMALS
THREATENED & ENDANGERED SNAILS
T. & E. TERRESTRIAL FLORA
T. & E. MAMMALS
T. & E. SNAILS
T. & E. TERRESTRIAL FLORA
MIDDLE RIVER
GREAT III
IMPACTS ON THREATENED AND ENDANGERED SPECIES
LEGEND
Starting / Milestone Point of Study
Study Duration (Relative Length of Time)
Time Interval between Annual Collection Periods

3

Table 5.0 Summary of data availability of biota by region.

Biota \ Region	GREAT I	Pool 4	GREAT II	Pool 19	GREAT III	Middle River
Threatened & Endangered Species						
Fish	+	0	+	0	+	+
Mussels	+	+	+	+	+	+
Mammals	0	0	0	0	0	0
Birds	+	+	+	+	+	+
Reptiles	+	0	0	0	+	+
Amphibians	+	0	0	0	+	+
Macrophytes	0	0	+	0	+	+
Snails	0	0	0	0	0	0
Terrestrial Flora	0	0	0	0	0	0
Indigenous Communities						
Fish						
Eggs & Larvae	+	+	+	0	0	0
Juveniles	+	+	+	0	0	0
Adults						
Spawning/Reproduction	+	+	+	0	+	+
Age/Growth	+	+	+	+	+	+
Feeding Habits	+	+	+	0	0	0
Distribution/Abundance	+	+	+	+	+	+
Parasites/Diseases	+	0	+	0	0	0
Management	+	+	+	+	+	+
Mussels	+	+	+	+	+	0
Benthos	+	+	+	+	+	+
Amphibians	+	0	+	0	+	+
Reptiles	+	0	+	0	+	+
Birds						
Waterfowl	+	+	+	+	+	+
Raptors	+	0	+	+	+	+
Other Birds	+	0	+	0	+	0
Mammals	+	+	+	0	+	+
Macrophytes	+	0	+	+	+	+
Periphyton	+	+	+	0	+	0
Phytoplankton	+	+	+	+	+	+
Zooplankton	+	+	+	0	+	0
Terrestrial Flora	0	0	0	0	0	0

+ = data present
0 = data void

Table 6.0 Summary of data availability of physical/chemical alterations by region.

Physical/chemical Alterations \ Region	GREAT I	Pool 4	GREAT II	Pool 19	GREAT III	Middle River
Habitat Alterations						
Sedimentation & Resuspension	+	+	+	+	+	+
Physical Removal & Disruption	+	+	+	+	+	+
Burial	+	+	+	+	+	+
Desiccation	+	+	+	+	+	+
Inundation	+	+	+	+	+	+
Velocity/Flow	+	+	+	+	0	0
Water Quality						
Turbidity	+	+	+	+	+	+
Toxic Substances	+	+	+	+	+	+
Oxygen Related	+	+	+	+	+	+
Nutrient Related	+	+	+	+	+	+
pH Related	+	+	+	+	+	+

+ = data present
0 = data void

5.0 Task D

The original objective of Task D was to provide specific information regarding the prioritized issues identified in Task C. The information to be provided included: 1) the administrative agency responsible for the study; 2) the cooperative agencies; 3) the objectives of each study; and 4) the estimated time and costs to complete the studies. This information was to be provided for each of the first 20 prioritized issues identified in Task C. After discussion with the Fish and Wildlife Management Work Group of GREAT II, it was determined that providing this specific information for the generalized studies identified in Task C was not feasible. Ultimately, a more generic approach was chosen, whereby generalized information was provided for all the studies without being specific to a particular one.

5.1 The Administrative Agency

For each study identified in Task C, the administrative agency should be that organization having regulatory responsibility for the potential impact to the river. For most maintenance and construction activities, the administrative agency should be the U.S. Army Corps of Engineers, or the city or municipality responsible for the activity. More encompassing activities, such as studies of submergent characteristics or endangered species, should be coordinated by the U.S. Fish and Wildlife Service. Waste water discharge impact studies should be administered by an appropriate state or federal regulatory agency in cooperation with the industry or municipality responsible for the discharge. Non point source discharge impact studies should be administered by the Soil Conservation Service of the U.S. Department of Agriculture.

5.2 Cooperative Agencies

The cooperative agencies will be those state and federal agencies that are responsible for the environmental quality of the Upper Mississippi River in addition to the organization contracted to do the study. Such state and federal agencies will be the U.S. Environmental Protection Agency, State water quality agencies, the U.S. Fish and Wildlife Service, as well as the Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Iowa Conservation Commission, Illinois Department of Conservation, and/or the Missouri Department of Conservation depending upon where the study is to be conducted. Additional coordination should be sought from the Upper Mississippi River Conservation Committee and Upper Mississippi River Basin Commission.

5.3 Study Objectives

The objectives of all the studies are basically similar; that is, to determine the impact of a particular activity on the particular type of biota being studied. However, specific objectives of the studies are highly variable and will depend upon the type of biota being studied, i.e., fish, birds, plankton, etc., and on the type and magnitude of the activity whose potential impacts are being studied, i.e., channel maintenance, point source discharges, navigation, etc. The specific objectives of each study will also depend upon whether the biota are listed as threatened or endangered, or whether they commonly occur in the Upper Mississippi River. Also pertinent to the specific objectives of the studies are the particular behavioral aspects of the biota being studied, i.e., spawning and reproduction, feeding habits, etc.

5.4 Time and Cost to Complete

The time required to complete the studies and the estimated costs will again depend upon the type of biota and the particular impact activity being studied. Some survey type studies, such as the determination of the impact of a point source discharge on the plankton population, will be relatively short in time (one to two years), and consequently lower in total cost. Other studies such as the effects of navigation on fishery resources could take several years to complete and would therefore reflect a much greater cost. Another factor influencing the cost of the study is the type of equipment needed to carry it out. Some benthos studies may not require much in terms of sophisticated equipment, whereas, some fish studies may, depending upon the number and kinds of fish collection methods employed.

APPENDIX A

Task A and B Tables

Table 1. Numbers of citations dealing with rare and endangered species of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Rare and Endangered Species

Subject	Pool											GREAT I
	1	2	3	4	5	5A	6	7	8	9	10	Region
Freshwater mussels	1	1	0	2	2	2	1	2	4	2	4	1
Fish	0	0	0	0	0	0	0	0	0	0	0	7
Amphibians	0	0	0	0	0	0	0	0	0	0	0	1
Reptiles	0	0	0	0	0	0	0	0	0	0	0	1
Birds	0	0	0	0	0	0	0	0	0	0	2	7
Aquatic vegetation	0	0	0	0	0	0	0	0	0	0	0	1
Other species	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Numbers of citations dealing with rare and endangered species of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Rare and Endangered Species

Subject	Pool												GREAT II
	11	12	13	14	15	16	17	18	19	20	21	22	Region
Freshwater mussels	2	4	3	4	6	4	5	4	4	4	3	4	1
Fish	0	0	0	0	0	0	0	0	0	0	0	0	11
Amphibians	0	0	0	0	0	0	0	0	0	1	1	1	0
Reptiles	0	0	0	0	0	0	0	0	0	1	1	1	0
Birds	0	0	0	0	3	0	0	1	0	0	0	0	8
Aquatic vegetation	0	0	0	0	0	0	0	0	1	1	1	1	1
Other spepcies	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Numbers of citations dealing with rare and endangered species of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Rare and Emdangered Species

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Freshwater mussels	2	1	1	1	1	22
Fish	0	0	0	0	6	1
Amphibians	0	0	0	0	1	0
Reptiles	0	0	0	0	1	0
Birds	2	0	1	1	5	67
Aquatic vegetation	0	0	0	0	6	1
Other species	0	0	0	0	0	0

Table 4. Numbers of citations *dealing with* plankton of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Plankton

Subject	Pool											GREAT I
	1	2	3	4	5	5A	6	7	8	9	10	Region
Phytoplankton	2	3	5	4	3	0	7	0	0	0	0	4
Zooplankton	0	1	3	1	1	0	1	0	0	0	0	4
Periphyton	0	0	0	2	0	0	0	0	0	0	0	8

Table 5. Numbers of citations dealing with plankton of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Plankton

Subject	Pool												GREAT II Region
	11	12	13	14	15	16	17	18	19	20	21	22	
Phytoplankton	0	2	0	13	0	0	0	0	2	1	0	0	3
Zooplankton	0	0	0	12	0	0	0	0	0	0	0	0	3
Periphytoan	0	0	0	16	0	0	0	0	0	0	0	0	0

Table 6. Numbers of citations dealing with plankton of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Plankton

Subject	Pool 24	25	26	Lower Stretch	GREAT III Region	Upper Mississippi River
Phytoplankton	0	0	0	1	7	6
Zooplankton	0	0	0	0	5	6
Periphyton	0	0	0	0	1	1

Table 7. Numbers of citations dealing with molluscs of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Molluscs

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Freshwater mussels	3	2	2	10	8	7	8	8	6	5	9	11
Fingernail clams	0	0	0	0	0	0	0	0	0	0	1	4
Other molluscs	0	0	0	0	0	0	0	0	0	2	2	8

Table 8. Numbers of citations dealing with molluscs of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Molluscs

Subject	Pool												GREAT II
	11	12	13	14	15	16	17	18	19	20	21	22	Region
Freshwater mussels	4	11	10	11	13	18	11	11	11	10	6	8	11
Fingernail clams	0	0	0	0	0	1	3	1	13	0	0	0	5
Other molluscs	0	0	2	9	1	3	4	2	1	0	0	0	5

Table 9. Numbers of citations dealing with molluscs of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Molluscs

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Freshwater mussels	2	1	1	0	10	34
Fingernail clams	0	0	0	0	1	2
Other molluscs	0	1	1	4	1	1

Table 10. Numbers of citations dealing with benthos other than molluscs of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Benthos (Excluding Molluscs)

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Aquatic insects	16	0	3	6	1	2	10	0	2	4	1	11
Miscellaneous macroinvertebrates	11	0	3	4	1	2	12	0	2	4	1	6

Table 11. Numbers of citations dealing with benthos other than molluscs of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Benthos (Excluding Molluscs)

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Aquatic insects	0	3	1	19	2	2	2	1	16	2	3	0	3
Miscellaneous macroinvertebrates	0	3	1	19	2	2	2	1	9	2	1	0	0

Table 12. Numbers of citations dealing with benthos other than molluscs of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Benthos (Excluding Molluscs)

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Aquatic insects	1	2	1	6	3	16
Miscellaneous macroinvertebrates	1	2	1	6	0	0

Table 13. Numbers of citations dealing with macrophytes of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Macrophytes

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Macrophytes	1	2	0	0	8	0	3	5	5	5	1	1

Table 14. Numbers of citations dealing with macrophytes of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Macrophytes

Subject	Pool												GREAT II Region
	11	12	13	14	15	16	17	18	19	20	21	22	
Macrophytes	1	1	1	2	1	1	1	1	1	1	1	1	2

Table 15. Numbers of citations dealing with macrophytes of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Macrophytes

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Macrophytes	0	0	0	4	2	11

Table 16. Numbers of citations dealing with sport fish of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Sport Fish

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Spawning and reproduction	1	0	1	2	0	1	1	2	6	7	4	3
Age and growth	0	0	3	6	1	0	2	1	4	10	5	10
Feeding habits	2	0	1	1	1	1	4	0	2	0	0	1
Distribution, movement and abundance	0	0	1	2	0	0	4	3	4	5	2	10
Management techniques	1	1	2	16	12	0	2	39	17	24	11	24
Parasites and diseases	1	0	0	0	0	0	5	0	0	0	0	0

Table 17. Numbers of citations dealing with sport fish of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Sport Fish

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Spawning and reproduction	6	0	8	1	0	0	1	4	0	0	0	0	2
Age and growth	9	2	10	10	1	1	3	5	3	0	0	0	9
Feeding habits	0	0	0	7	0	0	0	0	0	0	0	0	0
Distribution, movement and abundance	11	1	5	4	3	3	3	5	4	1	0	0	9
Management techniques	25	8	21	6	4	4	6	17	3	2	1	1	26
Parasites and diseases	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 18. Numbers of citations dealing with sport fish of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Sport Fish

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Spawning and reproduction	0	0	0	1	2	4
Age and growth	0	0	0	2	2	4
Feeding habits	0	0	0	0	0	3
Distribution, movement and abundance	0	0	0	0	1	10
Management techniques	1	1	7	1	3	18
Parasites and diseases	0	0	0	0	0	0

Table 19. Numbers of citations dealing with commercial fish of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Commercial Fish

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Spawning and reproduction	1	0	1	1	0	1	1	0	0	6	2	2
Age and growth	0	0	1	4	0	1	1	0	3	10	3	11
Feeding habits	1	0	0	0	1	0	1	0	1	0	0	0
Distribution, movement and abundance	0	0	0	1	0	0	1	2	0	7	1	6
Management techniques	0	0	0	1	0	0	2	5	3	8	5	15
Harvest and gear evaluation	0	0	1	4	1	1	2	9	7	11	9	20
Parasites and diseases	1	0	0	0	0	0	2	0	0	0	0	0

Table 20. Numbers of citations dealing with commercial fish of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Commercial Fish

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Spawning and reproduction	6	0	7	0	0	0	0	4	0	0	0	0	2
Age and growth	8	2	8	1	1	1	3	5	1	0	0	0	10
Feeding habits	0	0	0	0	0	0	0	0	0	0	0	0	0
Distribution, movement and abundance	7	1	7	3	3	3	3	7	3	0	0	0	6
Management techniques	8	4	7	3	3	2	3	6	2	0	0	0	15
Harvest and gear evaluation	11	9	9	8	8	7	7	8	7	1	1	1	21
Parasites and diseases	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 21. Numbers of citations dealing with commercial fish of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Commercial Fish

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Spawning and reproduction	0	0	0	1	1	2
Age and growth	0	0	0	2	1	2
Feeding habits	0	0	0	0	0	2
Distribution, movement and abundance	0	0	0	0	1	8
Management techniques	0	0	0	1	2	12
Harvest and gear evaluation	1	1	1	2	4	46
Parasites and diseases	0	0	0	0	0	0

Table 22. Numbers of citations dealing with forage fish of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Forage Fish

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Spawning and reproduction	0	0	0	0	0	0	0	0	0	0	0	0
Age and growth	1	0	0	0	0	0	0	0	1	0	0	1
Feeding habits	1	0	0	0	0	0	0	0	1	0	0	1
Distribution, movement and abundance	3	0	0	0	0	0	0	0	0	0	0	1
Management techniques	0	0	0	0	0	0	0	0	0	0	0	0
Parasites and diseases	0	0	0	0	0	0	0	0	0	0	0	0

Table 23. Numbers of citations dealing with forage fish of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Forage Fish

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Spawning and reproduction	0	0	0	0	0	0	0	0	0	0	0	0	0
Age and growth	0	0	0	0	0	0	0	0	0	0	0	0	0
Feeding habits	0	0	0	0	0	0	0	0	1	0	0	0	0
Distribution, movement and abundance	0	0	0	0	0	0	0	0	0	0	0	0	0
Management techniques	0	0	0	0	0	0	0	0	0	0	0	0	0
Parasites and diseases	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 24. Numbers of citations dealing with forage fish of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Forage Fish

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Spawning and reproduction	0	0	0	0	0	1
Age and growth	0	0	0	0	0	2
Feeding habits	0	0	0	0	0	1
Distribution, movement and abudance	0	0	0	0	0	8
Management techniques	0	0	0	0	0	0
Parasites and diseases	0	0	0	0	0	0

Table 25. Numbers of citations dealing with general fisheries of the Upper Mississippi River by Pool.

Region: GREAT I

Category: General Fisheries

Subject	Pool											GREAT I
	1	2	3	4	5	5A	6	7	8	9	10	Region
Spawning and reproduction	0	0	0	0	0	0	0	0	0	0	0	0
Age and growth	1	0	0	0	0	0	0	0	0	0	0	0
Feeding habits	0	0	0	0	0	0	0	0	0	0	0	1
Distribution, movement and abundance	9	3	3	7	3	2	3	3	7	3	2	14
Management techniques	0	0	0	1	0	0	1	3	4	5	2	5
Parasites and diseases	0	0	0	0	0	0	1	1	0	0	0	0
Taxonomy	0	0	0	0	0	0	0	0	0	0	0	8

Table 26. Numbers of citations dealing with general fisheries of the Upper Mississippi River by Pool.

Region: GREAT II

Category: General Fisheries

Subject	Pool												GREAT II
	11	12	13	14	15	16	17	18	19	20	21	22	Region
Spawning and reproduction	0	0	0	6	0	0	0	0	0	0	0	0	0
Age and growth	0	0	0	0	0	0	0	0	0	0	0	0	0
Feeding habits	0	0	0	0	0	0	0	0	7	0	0	0	1
Distribution, movements and abundance	3	5	9	18	4	6	4	8	9	3	4	1	15
Management techniques	5	2	2	2	2	4	2	3	2	0	0	0	3
Parasites and diseases	0	0	0	8	0	0	0	0	2	0	0	0	0
Taxonomy	0	0	0	0	0	0	0	0	0	0	0	0	10

Table 27. Numbers of citations dealing with general fisheries of the Upper Mississippi River by Pool.

Region: GREAT III

Category: General Fisheries

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Spawning and reproduction	0	0	0	0	0	0
Age and growth	0	0	0	0	0	4
Feeding habits	0	0	0	0	0	3
Distribution, movement and abundance	3	5	4	9	5	12
Management techniques	0	0	0	1	0	10
Parasites and diseases	0	0	0	0	0	3
Taxonomy	0	0	0	0	4	0

Table 28. Numbers of citations dealing with amphibians and reptiles of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Amphibians and Reptiles

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Amphibians	0	0	0	0	0	0	1	3	3	3	1	2
Reptiles	0	0	0	0	1	1	2	0	0	0	0	2

Table 29. Numbers of citations dealing with amphibians and reptiles of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Amphibians and Reptiles

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Amphibians	0	0	0	0	0	0	0	0	0	0	1	0	0
Reptiles	0	0	0	0	0	0	0	1	0	0	1	0	0

Table 30. Numbers of citations dealing with amphibians and reptiles of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Amphibians and Reptiles

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Amphibians	0	0	0	12	5	8
Reptiles	0	0	0	14	6	16

Table 31. Numbers of citations dealing with waterfowl of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Waterfowl

Subject	Pool											GREAT I
	1	2	3	4	5	5A	6	7	8	9	10	Region
Nesting and rearing	0	0	0	0	0	0	0	0	0	0	0	2
Feeding	0	0	0	0	1	0	0	5	4	4	0	0
Distribution and abundance	0	0	0	0	1	0	0	0	0	0	0	0
Habitat	0	0	0	0	0	0	0	1	0	0	0	1
Management techniques	0	0	0	0	0	0	0	0	0	0	0	0

Table 32. Numbers of citations dealing with waterfowl of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Waterfowl

Subject	Pool												GREAT II Region
	11	12	13	14	15	16	17	18	19	20	21	22	
Nesting and rearing	2	0	0	0	0	0	0	0	0	0	0	0	0
Feeding	0	0	0	0	0	0	0	0	3	0	0	0	0
Distribution and abundance	0	0	0	0	0	0	0	0	4	0	0	0	0
Habitat	0	0	0	1	0	0	0	0	0	0	0	0	0
Management techniques	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 33. Numbers of citations dealing with waterfowl of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Waterfowl

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Nesting and rearing	0	0	0	0	0	5
Feeding	0	0	0	0	0	11
Distribution and abundance	0	0	0	0	0	15
Habitat	0	0	0	0	0	8
Management techniques	0	0	0	0	0	10

Table 34. Number of citations dealing with mammals and birds other than waterfowl of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Birds and Mammals

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Waterbirds	0	0	0	0	0	0	0	0	0	0	0	1
Mammals	0	0	0	0	0	0	0	1	0	1	0	0
General Wildlife	6	2	1	1	2	0	0	2	4	0	2	12

Table 35. Number of citations dealing with mammals and birds other than waterfowl of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Birds and Mammals

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Waterbirds	0	0	0	0	0	0	0	0	3	0	0	0	0
Mammals	0	1	0	0	0	0	0	0	0	0	1	0	0
General wildlife	0	0	0	0	1	0	0	0	3	0	1	0	9

Table 36. Numbers of citations dealing with mammals and birds other than waterfowl of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Birds and Mammals

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River
Waterbirds	0	0	0	5	0	2
Mammals	0	0	0	0	1	8
General wildlife	4	4	4	4	11	40

Table 37. Numbers of citations dealing with maintenance and construction activities of channels of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Maintenance/Construction-Channels

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Training structures	0	0	0	0	0	0	0	0	0	0	0	0
Closing structures	0	0	0	0	0	0	0	0	0	0	0	0
Wing dams	0	0	0	0	0	0	0	0	0	0	0	0
Revetments	0	0	0	0	0	0	0	0	0	0	0	0
Dredging disposal	2	2	0	1	2	1	1	1	7	1	2	0
Straightening	0	0	0	0	0	0	0	0	0	0	0	0
Degradation	1	2	1	2	2	1	2	1	2	1	2	0
Water level fluctuations	0	0	2	2	3	0	3	1	2	0	1	0
Navigation dams	2	0	1	1	0	0	0	0	1	0	2	0
General	5	3	2	4	7	5	6	6	9	5	4	4

Table 38. Numbers of citations dealing with maintenance and construction activities of channels of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Maintenance/Construction-Channels

Subject	Pool												GREAT II
	11	12	13	14	15	16	17	18	19	20	21	22	Region
Training structures	0	0	0	4	1	3	1	0	0	1	0	0	0
Closing structures	0	0	0	1	1	1	1	0	0	0	0	0	0
Wing dams	0	0	0	0	0	0	0	0	0	0	0	0	0
Revetments	0	0	0	2	0	0	0	0	0	0	0	0	0
Dredging disposal	1	1	1	1	1	1	0	0	0	0	0	0	1
Straightening	1	0	0	0	0	0	0	0	0	1	0	0	0
Degradation	1	1	1	1	1	1	0	0	5	2	1	0	1
Water level fluctuations	0	0	1	1	1	0	0	0	0	0	1	0	1
Navigation dams	0	0	2	1	2	0	0	0	2	2	0	0	0
General	3	2	3	2	2	1	1	1	2	1	0	0	8

Table 39. Numbers of citations dealing with maintenance and construction activities of channels of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Maintenance/Construction-Channels

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Training structures	0	0	0	1	1	1	12
Closing structures	0	0	1	0	1	1	0
Wing dams	0	0	0	0	0	2	0
Revetments	0	0	0	0	1	1	2
Dredging disposal	0	1	0	2	0	7	39
Straightening	0	0	0	2	1	3	8
Degradation	0	0	0	5	3	11	33
Water level fluctuations	0	0	0	0	1	4	3
Navigation dams	0	0	19	0	2	4	22
General	2	3	3	14	5	31	69

Table 40. Numbers of citations dealing with maintenance and construction activities of harbors of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Maintenance/Construction-Harbors

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Dredging	0	0	0	0	0	0	0	0	0	0	0	0
Dredging disposal	0	0	0	0	0	0	0	0	0	0	0	0
Turbidity	0	0	0	0	0	0	0	0	0	0	0	0
Toxic material	0	0	0	0	0	0	0	0	0	0	0	0
General	1	0	0	1	0	0	0	0	0	0	0	0

Table 41. Numbers of citations dealing with maintenance and construction activities of harbors of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Maintenance/Construction-Harbors

	Pool												GREAT II
Subject	11	12	13	14	15	16	17	18	19	20	21	22	Region
Dredging	0	0	0	0	0	0	0	0	2	0	0	0	1
Dredging disposal	0	0	0	0	0	0	0	0	1	0	0	0	0
Turbidity	0	0	0	0	0	0	0	0	2	0	0	0	0
Toxic material	0	0	0	0	0	0	0	0	0	0	0	0	0
General	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 42. Numbers of citations dealing with maintenance and construction activities of harbors of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Maintenance/Construction-Harbors

	Pool			Lower	GREAT III	Upper Mississippi	Non-Upper
Subject	24	25	26	Stretch	Region	River	Mississippi River
Dredging	0	0	0	1	0	0	2
Dredging disposal	0	0	0	1	0	0	2
Turbidity	0	0	0	0	0	0	0
Toxic material	0	0	0	0	0	0	2
General	0	0	1	1	0	0	7

Table 43. Numbers of citations dealing with maintenance and construction activities of bridges and pipelines of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Maintenance/Construction-Bridges and Pipelines

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Fill	0	0	0	0	0	0	0	0	0	0	0	0
Channel alteration	0	0	0	0	0	0	0	0	0	0	0	0
Dredging	0	0	0	0	0	0	0	0	0	0	0	0
Dredging disposal	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline leakage	0	0	0	0	0	0	0	0	0	0	0	0
General	0	0	0	0	0	0	0	0	0	0	0	0

Table 44. Numbers of citations dealing with maintenance and construction activities of bridges and pipelines of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Maintenance/Construction-Bridges and Pipelines

Subject	Pool												GREAT II
	11	12	13	14	15	16	17	18	19	20	21	22	Region
Fill	0	0	0	0	0	0	0	0	0	0	0	0	0
Channel alteration	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredging	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredging disposal	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline leakage	0	0	0	0	0	0	0	0	0	0	0	0	0
General	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 45. Numbers of citations dealing with maintenance and construction activities of bridges and pipelines of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Maintenance/Construction-Bridges and Pipelines

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Fill	0	0	0	0	0	0	0
Channel alteration	0	0	0	0	0	0	0
Dredging	0	0	0	0	0	0	0
Dredging disposal	0	0	0	0	0	0	0
Pipeline leakage	0	0	0	0	0	0	0
General	0	0	0	0	0	0	0

Table 46. Numbers of citations dealing with reclamation and encroachment activities of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Reclamation and Encroachment

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Industrial	2	0	1	0	1	0	1	0	0	1	3	0
Municipal	0	0	1	0	0	0	1	0	0	0	2	0
Agricultural	0	0	0	0	0	0	0	0	0	0	0	0
Recreational	1	0	2	2	3	2	2	3	2	2	3	0
General	2	1	1	2	3	3	4	3	2	3	3	3

Table 47. Numbers of citations dealing with reclamation and encroachment activities of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Reclamation and Encroachment

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Industrial	1	2	1	3	1	2	3	1	1	0	0	0	1
Municipal	0	1	0	2	0	2	1	0	0	0	0	0	0
Agricultural	0	0	0	1	0	1	1	0	0	0	0	0	0
Recreational	2	3	2	4	1	1	1	1	2	1	2	0	8
General	2	1	1	2	2	2	1	2	1	0	0	1	0

Table 48. Numbers of citations dealing with reclamation and encroachment activities of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Reclamation and Encroachment

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Industrial	0	0	0	2	0	3	1
Municipal	0	0	0	2	0	0	1
Agricultural	0	0	0	1	0	3	1
Recreational	0	0	1	0	3	7	0
General	0	0	0	5	1	16	43

Table 49. Numbers of citations dealing with commercial navigation of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Navigation-Commercial

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Wave wash	0	0	0	0	0	0	0	0	0	0	0	0
Suspension of sediment and turbidity	0	0	0	0	0	0	0	1	0	0	0	0
Toxic spills	0	0	0	0	0	0	0	0	0	0	0	0
Displacement and tidal effects	0	0	0	0	0	0	0	0	0	0	0	0
Hazing of wildlife	0	1	0	0	0	0	0	0	0	0	0	0
Cold weather effects	1	0	0	0	0	0	0	0	0	0	0	0
General	3	2	0	0	0	0	1	0	1	1	0	1

Table 50. Numbers of citations dealing with commercial navigation of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Navigation-Commercial

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Wave wash	0	0	0	0	0	0	0	0	0	0	0	0	0
Suspension of sediments and turbidity	0	0	0	0	0	0	0	0	0	0	0	0	0
Toxic spills	0	0	0	0	0	0	0	0	0	0	0	0	0
Displacement and tidal effects	0	0	0	0	0	0	0	0	0	0	0	0	0
Hazing of wildlife	0	0	0	0	0	0	0	0	1	0	0	0	0
Cold weather effects	0	1	0	0	0	0	0	0	2	1	1	1	3
General	0	1	1	1	1	1	1	1	2	1	1	1	1

Table 51. Numbers of citations dealing with commercial navigation of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Navigation-Commercial

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Wave wash	0	0	0	0	0	1	1
Suspension of sediments and turbidity	0	0	0	0	0	4	5
Toxic spills	0	0	0	0	0	0	2
Displacement and tidal effects	0	0	0	0	0	1	4
Hazing of wildlife	0	0	0	0	0	2	0
Cold weather effects	0	0	0	0	2	2	52
General	0	0	0	1	1	9	26

Table 52. Numbers of citations dealing with recreational navigation of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Navigation-Recreational

Subject	Pool											GREAT I Region
	1	2	3	4	5	5A	6	7	8	9	10	
Hazing of wildlife	0	0	0	0	0	0	0	0	0	0	0	0
Wave wash	0	0	0	0	0	0	0	0	0	0	0	0
Suspension of sediments	0	0	0	0	0	0	0	0	0	0	0	0
Turbidity	0	0	0	0	0	0	0	0	0	0	0	0
General	4	3	1	1	1	1	1	1	1	2	0	0

Table 53. Numbers of citations dealing with recreational navigation of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Navigation-Recreational

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Hazing of wildlife	0	0	0	0	0	0	0	0	2	0	0	0	0
Wave wash	0	0	0	0	0	0	0	0	0	0	0	0	0
Suspension of sediments	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbidity	0	0	0	0	0	0	0	0	0	0	0	0	0
General	0	1	1	1	1	1	1	1	1	1	1	1	1

Table 54. Numbers of citations dealing with recreational navigation of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Navigation-Recreational

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Hazing of wildlife	0	0	0	0	0	0	0
Wave wash	0	0	0	0	0	1	0
Suspension of sediments	0	0	0	0	0	1	2
Turbidity	0	0	0	0	0	0	1
General	0	0	0	0	1	0	5

Table 55. Numbers of citations dealing with general water quality of the Upper Mississippi River by Pool.

Region: GREAT I

Category: General Water Quality

	Pool											GREAT I
Subject	1	2	3	4	5	5A	6	7	8	9	10	Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	5
Surveys	25	11	6	6	5	4	9	8	5	3	0	25

Table 56. Numbers of citations dealing with general water quality of the Upper Mississippi River by Pool.

Region: GREAT II

Category: General Water Quality

Subject	Pool												GREAT II Region
	11	12	13	14	15	16	17	18	19	20	21	22	
Regulations	0	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	1	3	3	10	3	3	3	5	5	2	0	0	12

Table 57. Numbers of citations dealing with general water quality of the Upper Mississippi River by Pool.

Region: GREAT III

Category: General Water Quality

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Regulations	0	0	0	0	5	3	0
Surveys	2	2	3	7	3	41	0

Table 58. Numbers of citations dealing with industrial waste discharges into the Upper Mississippi River by Pool.

Region: GREAT I

Category: Waste Discharges-Industrial

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0
Surveys of thermal effects	12	0	4	0	2	1	0	0	0	2	0	0
Surveys of chemical effects	3	0	0	0	0	0	1	0	0	0	0	4
Surveys of spill effects	1	1	1	1	0	0	0	0	0	0	0	2

Table 59. Numbers of citations dealing with industrial waste discharges into the Upper Mississippi River by Pool.

Region: GREAT II

Category: Waste Discharges-Industrial

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0	0
Surveys of thermal effects	0	0	0	48	0	0	0	0	1	0	0	0	0
Surveys of chemical effects	0	0	0	3	0	0	0	0	0	0	0	0	3
Surveys of spill effects	0	0	1	0	0	0	0	0	0	0	0	0	0

Table 60. Numbers of citations dealing with industrial waste discharges into the Upper Mississippi River by Pool.

Region: GREAT III

Category: Waste Discharges-Industrial

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Regulations	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0
Surveys of thermal effects	0	0	0	0	0	21	0
Surveys of chemical effects	0	0	0	2	1	12	0
Surveys of spill effects	0	0	0	0	0	2	0

Table 61. Numbers of citations dealing with municipal waste discharges into the Upper Mississippi River by Pool.

Region: GREAT I

Category: Waste Discharges-Municipal

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	6	2	1	1	0	0	3	0	0	0	0	3

Table 62. Numbers of citations dealing with municipal waste discharges into the Upper Mississippi River by Pool.

Region: GREAT II

Category: Waste Discharges-Municipal

Subject	Pool												GREAT II
	11	12	13	14	15	16	17	18	19	20	21	22	Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	0	4	0	0	1	0	0	0	5	0	0	0	1

Table 63. Numbers of citations dealing with municipal waste discharges into the Upper Mississippi River by Pool.

Region: GREAT III

Category: Waste Disharges-Municipal

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Regulations	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0
Surveys	0	0	0	3	1	5	0

Table 64. Numbers of citations dealing with agricultural waste discharges into the Upper Mississippi River by Pool.

Region: GREAT I

Category: Waste Discharges-Agricultural

Subject	Pool											GREAT I
	1	2	3	4	5	5A	6	7	8	9	10	Region
Regulations	1	1	1	1	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	2	2	2	3	0	0	0	1	2	2	0	11

Table 65. Numbers of citations dealing with agricultural waste discharges into the Upper Mississippi River by Pool.

Region: GREAT II

Category: Waste Discharges-Agricultural

Subject	Pool 11	12	13	14	15	16	17	18	19	20	21	22	GREAT II Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	1	1	0	0	0	0	1	0	1	0	0	0	8

Table 66. Numbers of citations dealing with agricultural waste discharges into the Upper Mississippi River by Pool.

Region: GREAT III

Category: Waste Discharges-Agricultural

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Regulations	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0
Surveys	0	0	0	1	1	21	0

Table 67. Numbers of citations dealing with recreational waste discharges into the Upper Mississippi River by Pool.

Region: GREAT I

Category: Waste Discharges-Recreational

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	0	0	0	0	0	0	0	0	0	0	0	0

Table 68. Numbers of citations dealing with recreational waste discharges into the Upper Mississippi River by Pool.

Region: GREAT II

Category: Waste Discharges-Recreational

	Pool												GREAT II
Subject	11	12	13	14	15	16	17	18	19	20	21	22	Region
Regulations	0	0	0	0	0	0	0	0	0	0	0	0	0
Violations	0	0	0	0	0	0	0	0	0	0	0	0	0
Standards	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0	0	0	0	0	0	0
Surveys	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 69. Numbers of citations dealing with recreational waste discharges into the Upper Mississippi River by Pool.

Region: GREAT III

Category: Waste Discharges-Recreational

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Regulations	0	0	0	0	0	0	2
Violations	0	0	0	0	0	0	0
Standarads	0	0	0	0	0	0	0
Fish kills	0	0	0	0	0	0	0
Surveys	0	0	0	0	0	0	4

Numbers of citations dealing with sedimentation and erosion of the Upper Mississippi River by Pool.

Region: GREAT I

Category: Sedimentation/Erosion

Subject	Pool 1	2	3	4	5	5A	6	7	8	9	10	GREAT I Region
Upland	0	0	0	0	0	0	0	0	0	0	0	0
Stream bank	0	0	0	0	0	0	0	0	0	0	0	0
Backwaters	0	0	0	1	1	0	0	1	0	2	0	0
Bed degradation	0	0	0	1	0	0	0	0	1	1	0	0
General	3	0	0	0	0	0	0	1	0	0	0	1

Table 71. Numbers of citations dealing with sedimentation and erosion of the Upper Mississippi River by Pool.

Region: GREAT II

Category: Sedimentation/Erosion

	Pool												GREAT II
Subject	11	12	13	14	15	16	17	18	19	20	21	22	Region
Upland	0	0	0	0	0	0	0	0	0	0	0	0	0
Stream bank	0	0	0	0	0	0	0	0	0	0	0	0	0
Backwaters	0	0	0	0	0	0	0	0	0	0	0	0	0
Bed degredation	0	0	0	0	0	0	0	0	0	0	0	0	0
General	0	0	0	0	0	1	1	1	2	2	2	1	1

Table 72. Numbers of citations dealing with sedimentation and erosion of the Upper Mississippi River by Pool.

Region: GREAT III

Category: Sedimentation/Erosion

Subject	Pool 24	Pool 25	Pool 26	Lower Stretch	GREAT III Region	Upper Mississippi River	Non-Upper Mississippi River
Upland	0	0	0	0	0	4	0
Streambanks	0	0	0	0	0	6	1
Backwaters	0	0	0	0	0	2	0
Bed degredation	0	0	0	3	0	3	2
General	0	0	0	3	1	9	2

APPENDIX B

Task C Tables

NOTE: The numbers in the body of the following tables represent the data availability which was categorized in a numerical scheme for each activity and for each of the six geographical regions. The numerical scheme is defined as follows:

0 = no data available
1 = little data available
2 = average amount of data, old (pre 1965)
3 = average amount of data, recent
4 = an abundance of data, old (pre 1965)
5 = an abundance of recent data
* = category does not apply

APPENDIX B
LIST OF TABLES

Table C-1. Channel Maintenance and Construction.

Biota \ Physical/Chemical Alterations (GREAT I Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		1	1	1	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	0		0	*	*	*	*
Birds		*	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	*	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	0	0		3	3	3	0	0
Juveniles		3	0	0	0	0	0		3	3	3	3	0
Adults													
Spawning/Reproduction		3	0	0	3	0	0		3	3	0	0	0
Age/Growth		5	0	0	3	*	0		5	5	3	3	3
Feeding Habits		3	0	0	0	0	0		3	3	0	3	0
Distribution/Abundance		5	0	0	3	0	0		5	3	3	3	3
Parasites/Diseases		3	*	*	*	*	*		3	3	0	0	0
Management		5	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	*	0		3	1	0	0	0
Benthos		5	5	5	0	0	0		3	3	3	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	*	*	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	*	0	0	0	0		0	*	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		5	*	*	0	*	0		0	0	0	0	0
Zooplankton		3	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-1. Continued.

Biota \ Physical/Chemical Alterations (Pool 4)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		1	1	1	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	0		0	*	*	*	*
Birds		*	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	*	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		3	3	3	0	0
Juveniles		3	0	0	0	0	0		3	3	3	3	0
Adults													
Spawning/Reproduction		3	0	0	0	0	0		3	0	0	0	0
Age/Growth		3	0	0	0	*	0		3	3	3	3	3
Feeding Habits		3	0	0	0	0	0		3	3	0	3	0
Distribution/Abundance		3	0	0	0	0	0		3	3	3	3	3
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		5	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	*	0		3	1	0	0	0
Benthos		3	3	3	0	0	0		3	3	3	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	*	*	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	*	0	0	0	0		0	*	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		3	*	*	0	*	0		0	0	0	0	0
Zooplankton		3	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-1. Continued.

GREAT II Area

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	0		0	*	*	*	*
Birds		*	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	*		0	*	*	*	*
Amphibians		0	*	0	0	0	0		0	0	0	0	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	*
Snails		0	0	0	0	*	0		0	0	0	0	*
Terrestrial Flora		*	0	0	*	0	0		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		5	0	0	0	0	0		3	3	3	0	0
Juveniles		5	0	0	0	0	0		3	3	3	3	0
Adults													
Spawning/Reproduction		3	0	0	0	0	0		3	0	0	0	0
Age/Growth		5	0	0	*	*	0		3	3	3	3	3
Feeding Habits		3	0	0	0	0	0		3	0	0	1	0
Distribution/Abundance		5	0	0	*	0	0		3	3	3	3	3
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		5	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	5	0	*	0		5	3	3	3	1
Benthos		5	5	5	0	0	0		3	3	3	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	*	*	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	*	0	0	0	0		0	*	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		5	*	*	0	*	0		3	0	3	0	0
Zooplankton		5	*	*	0	*	0		3	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-1. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		1	1	1	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	0		0	*	*	*	*
Birds		*	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	*	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		0	0	0	0	0
Juveniles		0	0	0	0	0	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	*	0	0		0	0	0	0	0
Age/Growth		1	0	0	*	*	0		0	0	0	0	*
Feeding Habits		0	0	0	0	0	0		0	0	0	0	0
Distribution/Abundance		3	0	0	*	0	0		3	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	5	0	*	0		3	3	0	0	0
Benthos		5	3	3	0	0	0		3	3	3	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	*	*	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	*	0	0	0	0		0	*	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		3	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-1. Continued.

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
	GREAT III Area												
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	0		0	*	*	*	*
Birds		*	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	*	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		0	0	0	0	0
Juveniles		0	0	0	0	0	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	0	0	*	0	0		0	0	0	*	*
Age/Growth		1	0	0	*	*	0		0	0	0	0	*
Feeding Habits		0	0	0	0	0	0		0	0	0	0	0
Distribution/Abundance		3	0	0	*	0	0		1	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	0	0	0	0	0		0	0	0	0	0
Mussels		4	2	2	0	*	0		2	2	0	0	0
Benthos		3	3	3	0	0	0		3	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	*
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	*	*	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	*	0	0	0	0		0	*	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-1. Continued.

Biota \ Physical/Chemical Alterations (Middle River)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		1	1	1	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	0		0	*	*	*	*
Birds		*	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	*	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		0	0	0	0	0
Juveniles		0	0	0	0	0	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	0	0	*	0	0		0	0	0	0	0
Age/Growth		1	0	0	*	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	0	0		0	0	0	0	0
Distribution/Abundance		1	0	0	*	0	0		1	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		1	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		3	3	0	0	0	0		3	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	*	*	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	*	0	0	0	0		0	*	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-2. Harbor, Levee and Breakwall Construction and Maintenance.

Biota \ Physical/Chemical Alterations (GREAT I Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		*	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	*	0		3	3	0	0	0
Juveniles		3	0	0	0	*	0		3	3	0	0	0
Adults													
Spawning/Reproduction		3	3	0	0	*	0		3	3	0	0	0
Age/Growth		3	3	0	0	*	0		3	3	3	3	3
Feeding Habits		3	0	0	0	*	0		3	3	0	3	0
Distribution/Abundance		5	3	0	0	0	0		3	3	3	3	3
Parasites/Diseases		1	*	*	*	*	*		0	0	0	0	0
Management		3	3	0	0	0	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		3	0	0	0	0
Benthos		3	3	0	0	*	0		3	3	0	0	0
Amphibians		0	1	0	0	0	0		0	0	0	0	0
Reptiles		0	1	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	1	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-2. Continued.

Physical/Chemical Alterations → / Biota ↓ (Pool 4)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		*	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	0		1	0	0	0	0
Age/Growth		3	3	0	0	*	0		3	3	0	0	0
Feeding Habits		1	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	*	0	0	0	0		3	3	3	3	3
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	3	0	0	0	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		3	0	0	0	0
Benthos		3	0	0	0	*	0		3	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-2. Continued.

Biota \ Physical/Chemical Alterations (GREAT II Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		*	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	*	0		3	3	0	0	0
Juveniles		3	0	0	0	*	0		3	1	0	0	0
Adults													
Spawning/Reproduction		3	3	0	0	*	0		1	1	0	0	0
Age/Growth		3	3	0	0	*	0		3	3	3	3	3
Feeding Habits		3	1	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	3	0	0	0	0		3	3	3	3	3
Parasites/Diseases		3	3	*	*	*	*		3	0	0	0	0
Management		5	3	0	0	0	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		3	0	0	0	0
Benthos		3	3	0	0	*	0		3	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	1	0	0		0	1	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	1	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

AD-A096 480 HAZLETON ENVIRONMENTAL SCIENCES CORP NORTHBROOK IL F/G 6/6
GREAT RIVER ENVIRONMENTAL ACTION TEAM (GREAT II). LITERATURE RE--ETC(U)
DEC 80 DACW25-79-C-0066
UNCLASSIFIED ES-9057 NL

6 OF 6
AD A
096480

END
DATE
FILMED
4-81
DTIC

Table C-2. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		*	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		3	3	0	0	*	0		3	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	3	0	0	0	0		3	3	3	3	3
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	*	0	0	0	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		3	0	0	0	0
Benthos		3	0	0	0	*	0		3	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	0	0	0		0	1	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-2. Continued.

Biota \ Physical/Chemical Alterations (GREAT III Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		*	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	*	0	0	*	0		0	0	0	0	0
Age/Growth		1	1	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		0	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	*	0	0	0	0		0	0	0	0	0
Mussels		2	2	0	0	*	0		2	0	0	0	0
Benthos		1	0	0	0	*	0		1	0	0	0	0
Amphibians		1	1	1	1	0	0		1	0	1	0	0
Reptiles		1	1	0	0	1	0		1	0	*	*	0
Birds													
Waterfowl		0	1	0	0	0	0		0	1	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	1	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-2. Continued.

Biota \ Physical/Chemical Alterations (Middle River)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		*	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		0	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	*	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		1	1	1	1	0	0		1	0	0	0	0
Reptiles		1	1	0	0	1	0		1	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-3. Corridor Construction and Maintenance.

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
						GREAT I Area							
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		1	1	1	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	*	0		3	0	0	0	0
Juveniles		3	0	0	0	*	0		3	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	0		3	0	0	0	0
Age/Growth		3	0	0	0	*	0		3	3	3	0	0
Feeding Habits		3	0	0	0	*	0		3	0	0	3	0
Distribution/Abundance		3	3	0	0	0	0		3	3	3	3	3
Parasites/Diseases		1	*	*	*	*	*		0	0	0	0	0
Management		3	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-3. Continued.

Physical/Chemical Alterations → Biota ↓ (Pool 4)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		*	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		3	0	0	0	*	0		3	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	0		0	0	0	0	0
Age/Growth		3	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-3. Continued.

Biota \ Physical/Chemical Alterations (GREAT II Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		3	3	3	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	*	0	0
Juveniles		3	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	0		3	3	0	0	0
Age/Growth		3	0	0	0	*	0		3	3	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	3	0	0	0	0		3	3	3	3	3
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-3. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	*	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		1	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	*	0	*
Distribution/Abundance		3	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		1	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-3. Continued.

Physical/Chemical Alterations / Biota (GREAT III Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	*	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	0	0	0	*	0		0	0	0	0	0
Age/Growth		1	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		3	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		1	1	1	1	0	0		0	0	0	0	0
Reptiles		1	1	0	0	1	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-3. Continued.

Biota \ Physical/Chemical Alterations (Middle River)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		*	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	*	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	0	0	0	*	0		0	0	0	0	0
Age/Growth		1	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		0	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		1	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		1	1	1	1	0	0		0	0	0	0	0
Reptiles		1	1	0	0	1	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-4. Wingdam Construction and Maintenance.

GREAT I Area

Biota \ Physical/Chemical Alterations	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	3		0	0	0	0	0
Age/Growth		3	0	0	0	*	0		0	0	0	0	0
Feeding Habits		3	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	0	0	0	0	3		3	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	*	1		3	0	0	0	0
Benthos		3	3	3	0	*	3		3	0	3	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-4. Continued.

Physical/Chemical Alterations / Biota	Pool 4												
	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	*	1		3	0	0	0	0
Benthos		3	3	3	0	*	3		3	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	*	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-4. Continued.

Physical/Chemical Alterations / Biota	GREAT II Area: Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	0		0	0	0	0	0
Age/Growth		3	0	0	0	*	0		3	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	0	0	0	0	0		3	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	*	1		3	0	0	0	0
Benthos		3	3	3	0	*	3		3	0	3	0	3
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-4. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	C	*	1		3	0	0	0	0
Benthos		3	3	3	0	*	3		3	0	3	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-4. Continued.

GREAT III Area

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	0	0	0	0	0		0	0	0	0	0
Mussels		2	0	0	0	*	0		2	0	0	0	0
Benthos		1	1	0	0	*	0		1	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-4. Continued.

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
	Middle River												
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	*	*	*	*
Birds		0	0	0	0	0	*		0	*	*	*	*
Reptiles		0	0	0	0	0	0		0	*	*	*	*
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		0	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	0
Management		0	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		0	0	0	0	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	*	*	*
Raptors		0	0	0	0	0	*		0	0	*	*	*
Other Birds		0	0	0	0	0	*		0	0	*	*	*
Mammals		0	0	0	0	0	0		0	0	*	*	*
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	0	0	*	0	*		*	*	*	*	*

Table C-5. Mitigation.

Biota \ Physical/Chemical Alterations (GREAT I Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		3	3	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	0		0	0	*	*	0
Birds		0	5	0	0	0	0		0	0	*	*	0
Reptiles		1	1	0	0	0	0		0	0	0	0	0
Amphibians		1	1	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	0	0		0	0	0	0	0
Snails		0	0	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	0	0		3	3	0	0	0
Juveniles		3	3	0	0	0	0		3	3	3	3	3
Adults													
Spawning/Reproduction		3	3	0	3	0	0		3	3	3	0	0
Age/Growth		3	3	0	0	0	0		3	0	0	0	0
Feeding Habits		3	0	0	0	0	0		3	3	3	3	0
Distribution/Abundance		5	3	0	3	0	0		5	3	3	3	3
Parasites/Diseases		3	0	0	0	*	0		3	0	0	0	0
Management		5	3	0	3	0	0		0	0	0	0	0
Mussels		5	5	3	0	3	0		5	3	3	3	3
Benthos		5	5	3	3	3	0		5	3	3	3	3
Amphibians		1	0	0	0	0	0		1	0	0	0	0
Reptiles		1	0	0	0	0	0		1	0	*	*	0
Birds													
Waterfowl		0	3	1	1	1	0		0	3	0	0	0
Raptors		0	3	0	1	1	*		0	1	*	*	0
Other Birds		0	1	1	1	1	*		0	1	*	*	0
Mammals		0	1	1	1	1	0		0	1	0	*	0
Macrophytes		1	1	0	0	0	0		0	0	0	0	0
Periphyton		0	3	0	0	0	0		0	0	0	0	0
Phytoplankton		3	*	*	0	0	0		0	0	0	0	0
Zooplankton		3	*	*	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	*	*	*	*

Table C-5. Continued.

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
	Pool 4												
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	0		0	0	*	*	0
Birds		0	1	0	0	0	0		0	0	*	*	0
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	0	0		0	0	0	0	0
Snails		0	0	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		1	0	0	0	0	0		1	1	1	0	0
Juveniles		1	1	0	1	0	0		1	1	1	1	1
Adults													
Spawning/Reproduction		3	3	0	1	0	0		3	3	3	3	3
Age/Growth		3	3	0	3	0	0		3	3	3	3	3
Feeding Habits		1	1	0	0	0	0		1	1	0	0	0
Distribution/Abundance		3	3	0	1	0	0		3	3	1	1	1
Parasites/Diseases		0	0	0	0	*	0		0	0	0	0	0
Management		5	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	3	0		5	3	3	3	3
Benthos		5	3	3	3	3	0		3	3	3	3	3
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	0	0	0		0	1	0	0	0
Raptors		0	0	0	0	0	*		0	0	*	*	0
Other Birds		0	0	0	0	0	*		0	0	*	*	0
Mammals		0	1	0	0	0	0		0	0	0	*	0
Macrophytes		0	0	0	0	0	0		0	0	0	0	0
Periphyton		0	0	0	0	0	0		0	0	0	0	0
Phytoplankton		0	*	*	0	0	0		0	0	0	0	0
Zooplankton		0	*	*	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	*	*	*	*

Table C-5. Continued.

Biota \ Physical/Chemical Alterations (GREAT II Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		3	3	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	0		0	0	*	*	0
Birds		0	5	0	0	0	0		0	0	*	*	0
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	1	0	0	0	0		0	0	0	0	0
Snails		0	0	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		5	0	0	3	0	0		5	3	3	0	0
Juveniles		5	3	0	3	0	0		5	3	3	3	3
Adults													
Spawning/Reproduction		5	3	0	3	0	0		3	3	3	3	3
Age/Growth		3	3	0	3	0	0		3	3	3	1	3
Feeding Habits		3	1	0	1	0	0		3	1	1	1	1
Distribution/Abundance		5	3	0	3	0	0		5	5	3	3	3
Parasites/Diseases		3	0	0	0	*	0		0	0	0	0	0
Management		5	0	0	0	0	0		0	0	0	0	0
Mussels		5	5	3	0	3	0		5	3	3	3	3
Benthos		5	5	3	3	3	0		5	5	5	5	5
Amphibians		1	0	0	0	0	0		0	0	0	0	0
Reptiles		1	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	3	1	1	1	0		0	3	0	0	0
Raptors		0	3	0	1	1	*		0	1	*	*	0
Other Birds		0	1	0	0	0	*		0	1	*	*	0
Mammals		0	1	0	0	0	0		0	1	0	*	0
Macrophytes		1	1	0	0	0	0		1	0	0	0	0
Periphyton		0	3	0	0	0	0		3	3	0	0	0
Phytoplankton		3	*	*	0	0	3		3	3	0	0	0
Zooplankton		3	*	*	0	0	3		3	3	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	*	*	*	*

Table C-5. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	0		0	0	*	*	0
Birds		0	3	0	0	0	0		0	0	*	*	0
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	0	0		0	0	0	0	0
Snails		0	0	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		0	0	0	0	0
Juveniles		0	0	0	0	0	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	0	0		0	0	0	0	0
Age/Growth		1	1	0	1	0	0		1	1	0	0	0
Feeding Habits		0	0	0	0	0	0		0	0	0	0	0
Distribution/Abundance		3	1	0	1	0	0		3	3	1	1	1
Parasites/Diseases		0	0	0	0	*	0		0	0	0	0	0
Management		1	0	0	0	0	0		0	0	0	0	0
Mussels		3	3	3	0	3	0		3	3	3	3	3
Benthos		3	3	3	0	3	0		3	3	3	3	3
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	3	1	3	1	0		0	3	0	0	0
Raptors		0	1	0	1	1	*		0	1	*	*	0
Other Birds		0	0	0	0	0	*		0	0	*	*	0
Mammals		0	0	0	0	0	0		0	0	0	*	0
Macrophytes		1	0	0	0	0	0		0	0	0	0	0
Periphyton		0	0	0	0	0	0		0	0	0	0	0
Phytoplankton		0	*	*	0	0	0		0	0	0	0	0
Zooplankton		0	*	*	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	*	*	*	*

Table C-5. Continued.

Biota \ Physical/Chemical Alterations (GREAT III Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		1	1	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	0		0	0	*	*	0
Birds		0	5	0	0	0	0		0	0	*	*	0
Reptiles		1	1	0	0	0	0		0	0	0	0	0
Amphibians		1	1	0	0	0	0		0	0	0	0	0
Macrophytes		0	3	0	0	0	0		0	0	0	0	0
Snails		0	0	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		0	0	0	0	0
Juveniles		0	0	0	0	0	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	0	0	0	0	0		0	0	0	0	0
Age/Growth		1	0	0	0	0	0		1	0	0	0	0
Feeding Habits		0	0	0	0	0	0		0	0	0	0	0
Distribution/Abundance		1	1	0	0	0	0		1	0	0	0	0
Parasites/Diseases		0	0	0	0	*	0		0	0	0	0	0
Management		1	0	0	0	0	0		0	0	0	0	0
Mussels		1	1	0	0	0	0		0	0	0	0	0
Benthos		1	1	1	1	1	0		1	0	0	0	0
Amphibians		3	3	3	3	0	0		3	1	1	1	1
Reptiles		3	3	0	0	3	0		3	1	*	*	0
Birds													
Waterfowl		0	3	1	3	3	0		0	3	0	0	0
Raptors		0	1	0	1	1	*		0	1	*	*	0
Other Birds		0	1	1	1	1	*		0	1	*	*	0
Mammals		0	1	1	1	1	0		0	1	0	*	0
Macrophytes		1	0	0	0	0	0		0	0	0	0	0
Periphyton		0	1	0	0	0	0		0	0	0	0	0
Phytoplankton		1	*	*	0	0	0		0	0	0	0	0
Zooplankton		1	*	*	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	*	*	*	*

Table C-5. Continued.

Biota \ Physical/Chemical Alterations	Middle River: Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		1	1	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	0		0	0	*	*	0
Birds		0	3	0	0	0	0		0	0	*	*	0
Reptiles		1	1	0	0	0	0		0	0	0	0	0
Amphibians		1	1	0	0	0	0		0	0	0	0	0
Macrophytes		0	3	0	0	0	0		0	0	0	0	0
Snails		0	0	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	0	0		0	0	0	0	0
Juveniles		0	0	0	0	0	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	0	0	0	0	0		0	0	0	0	0
Age/Growth		1	0	0	0	0	0		0	0	0	0	0
Feeding Habits		0	0	0	0	0	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	0	0		0	0	0	0	0
Parasites/Diseases		0	0	0	0	*	0		0	0	0	0	0
Management		1	0	0	0	0	0		0	0	0	0	0
Mussels		0	0	0	0	0	0		0	0	0	0	0
Benthos		1	1	1	1	1	0		1	1	0	0	0
Amphibians		3	3	3	3	0	0		3	1	1	1	1
Reptiles		3	3	0	0	3	0		3	1	*	*	0
Birds													
Waterfowl		0	3	0	0	0	0		0	1	0	0	0
Raptors		0	1	0	0	0	*		0	1	*	*	0
Other Birds		0	0	0	0	0	*		0	0	*	*	0
Mammals		0	1	0	0	0	0		0	0	0	*	0
Macrophytes		1	0	0	0	0	0		0	0	0	0	0
Periphyton		0	0	0	0	0	0		0	0	0	0	0
Phytoplankton		0	*	*	0	0	0		0	0	0	0	0
Zooplankton		0	*	*	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	0	*	0	*		*	*	*	*	*

Table C-6. Encroachment.

GREAT I Area

Biota \ Physical/Chemical Alterations	Habitat Alterations						Water Quality Alterations				
	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species											
Fish	0	*	*	0	0	0	0	0	0	0	0
Mussels	0	*	0	0	0	0	0	0	0	0	0
Mammals	0	0	0	0	0	*	0	0	*	*	*
Birds	0	0	0	0	0	*	0	0	*	*	*
Reptiles	0	0	0	0	0	0	0	0	*	0	*
Amphibians	0	0	0	0	0	0	0	0	0	0	*
Macrophytes	0	*	0	0	0	0	0	0	0	0	*
Snails	0	*	0	0	0	0	0	0	0	0	0
Terrestrial Flora	0	0	*	0	0	*	*	*	*	*	*
Indigenous Communities											
Fish											
Eggs & Larvae	0	*	0	0	*	0	0	0	0	0	0
Juveniles	3	*	0	0	*	0	0	0	0	0	0
Adults											
Spawning/Reproduction	3	*	0	3	*	0	3	1	1	1	1
Age/Growth	3	*	0	0	*	0	3	3	1	1	1
Feeding Habits	3	*	0	1	*	0	3	1	0	1	0
Distribution/Abundance	5	*	0	3	*	0	3	3	3	0	0
Parasites/Diseases	1	*	*	0	*	0	0	0	0	0	*
Management	3	*	0	*	*	0	*	*	*	*	*
Mussels	3	*	0	3	*	0	0	0	0	0	0
Benthos	5	*	0	3	*	0	0	0	0	0	0
Amphibians	1	0	0	0	0	0	0	0	0	0	0
Reptiles	1	0	0	0	0	0	0	0	*	*	0
Birds											
Waterfowl	0	1	0	0	1	*	0	1	*	*	0
Raptors	0	1	*	0	0	*	0	0	*	*	0
Other Birds	0	0	*	0	0	*	0	0	*	*	0
Mammals	0	1	*	0	0	*	0	0	*	*	0
Macrophytes	0	*	0	0	*	0	0	0	0	0	0
Periphyton	0	*	0	0	*	0	0	0	0	0	0
Phytoplankton	0	*	0	0	*	0	0	0	0	0	0
Zooplankton	0	*	0	0	*	0	0	0	0	0	0
Terrestrial Flora	0	0	*	*	0	*	*	*	*	*	*

Table C-6. Continued.

Biota \ Physical/Chemical Alterations (Pool 4)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	0	0	0		0	0	0	0	0
Mussels		0	*	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	0	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	*	0	*
Amphibians		0	0	0	0	0	0		0	0	0	0	*
Macrophytes		0	*	0	0	0	0		0	0	0	0	*
Snails		0	*	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	*	0	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	0	*	0		0	0	0	0	0
Juveniles		0	*	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		1	*	0	0	*	0		0	0	0	0	0
Age/Growth		1	*	0	0	*	0		1	0	0	0	0
Feeding Habits		1	*	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	*	0	0	*	0		1	0	0	0	0
Parasites/Diseases		0	*	*	0	*	0		0	0	0	0	*
Management		3	*	0	*	*	0		*	*	*	*	*
Mussels		3	*	0	3	*	0		0	0	0	0	0
Benthos		3	*	0	3	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	*		0	0	*	*	0
Raptors		0	0	*	0	0	*		0	0	*	*	0
Other Birds		0	0	*	0	0	*		0	0	*	*	0
Mammals		0	0	*	0	0	*		0	0	*	*	0
Macrophytes		0	*	0	0	*	0		0	0	0	0	0
Periphyton		0	*	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	0	0	*	0		0	0	0	0	0
Zooplankton		C	*	0	0	*	0		0	0	0	0	0
Terrestrial Flora		0	0	*	*	0	*		*	*	*	*	*

Table C-6. Continued.

Physical/Chemical Alterations / Biota	GREAT II Area: Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	0	0	0		0	0	0	0	0
Mussels		0	*	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	0	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	*	0	*
Amphibians		0	0	0	0	0	0		0	0	0	0	*
Macrophytes		0	*	0	0	0	0		0	0	0	0	*
Snails		0	*	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	*	0	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	0	*	0		0	0	0	0	0
Juveniles		0	*	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	0	0	*	0		0	0	0	0	0
Age/Growth		3	*	0	1	*	0		3	1	0	0	0
Feeding Habits		1	*	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	*	0	3	*	0		3	3	3	1	1
Parasites/Diseases		0	*	*	*	*	0		0	0	0	0	*
Management		3	*	0	*	*	0		*	*	*	*	*
Mussels		3	*	0	3	*	0		0	0	0	0	0
Benthos		5	*	0	5	*	0		3	3	3	0	0
Amphibians		1	0	0	0	0	0		0	0	0	0	0
Reptiles		1	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	0	1	*		0	1	*	*	0
Raptors		0	0	*	0	0	*		0	0	*	*	0
Other Birds		0	1	*	0	0	*		0	0	*	*	0
Mammals		0	1	*	0	0	*		0	0	*	*	0
Macrophytes		0	*	0	0	*	0		0	0	0	0	0
Periphyton		0	*	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	0	0	*	0		0	0	0	0	0
Zooplankton		0	*	0	0	*	0		0	0	0	0	0
Terrestrial Flora		0	0	*	*	0	*		*	*	*	*	*

Table C-6. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	0	0	0		0	0	0	0	0
Mussels		0	*	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	0	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	*	0	*
Amphibians		0	0	0	0	0	0		0	0	0	0	*
Macrophytes		0	*	0	0	0	0		0	0	0	0	*
Snails		0	*	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	*	0	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	0	*	0		0	0	*	*	*
Juveniles		0	*	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	0	0	*	0		0	0	0	0	0
Age/Growth		1	*	0	0	*	0		0	0	0	0	0
Feeding Habits		0	*	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	*	0	0	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	0		0	0	0	0	*
Management		1	*	0	*	*	0		*	*	*	*	*
Mussels		3	*	0	3	*	0		0	0	0	0	0
Benthos		3	*	0	3	*	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	1	0	0	0	*		0	0	*	*	0
Raptors		0	0	*	0	0	*		0	0	*	*	0
Other Birds		0	0	*	0	0	*		0	0	*	*	0
Mammals		0	0	*	0	0	*		0	0	*	*	0
Macrophytes		0	*	0	0	*	0		0	0	0	0	0
Periphyton		0	*	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	0	0	*	0		0	0	0	0	0
Zooplankton		0	*	0	0	*	0		0	0	0	0	0
Terrestrial Flora		0	0	*	*	0	*		*	*	*	*	*

Table C-6. Continued.

Biota \ Physical/Chemical Alterations	Habitat Alterations						Water Quality Alterations				
	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
GREAT III Area											
Threatened & Endangered Species											
Fish	0	*	*	0	0	0	0	0	0	0	0
Mussels	0	*	0	0	0	0	0	0	0	0	0
Mammals	0	0	0	0	0	*	0	0	*	*	*
Birds	0	0	0	0	0	*	0	0	*	*	*
Reptiles	0	0	0	0	0	0	0	0	*	0	*
Amphibians	0	0	0	0	0	0	0	0	0	0	*
Macrophytes	0	*	0	0	0	0	0	0	0	0	*
Snails	0	*	0	0	0	0	0	0	0	0	0
Terrestrial Flora	0	0	*	0	0	*	*	*	*	*	*
Indigenous Communities											
Fish											
Eggs & Larvae	0	*	0	0	*	0	0	0	0	0	0
Juveniles	0	*	0	0	*	0	0	0	0	0	0
Adults											
Spawning/Reproduction	0	*	0	0	*	0	0	0	0	0	0
Age/Growth	0	*	0	0	*	0	0	0	0	0	0
Feeding Habits	0	*	0	0	*	0	0	0	0	0	0
Distribution/Abundance	0	*	0	0	*	0	0	0	0	0	0
Parasites/Diseases	0	*	*	*	*	0	0	0	0	0	*
Management	1	*	0	*	*	0	*	*	*	*	*
Mussels	0	*	0	0	*	0	0	0	0	0	0
Benthos	0	*	0	0	*	0	0	0	0	0	0
Amphibians	1	0	0	1	0	0	1	1	0	0	1
Reptiles	1	0	0	0	1	0	1	1	*	*	0
Birds											
Waterfowl	0	1	0	0	1	*	0	1	*	*	0
Raptors	0	0	*	0	0	*	0	0	*	*	0
Other Birds	0	1	*	0	0	*	0	0	*	*	0
Mammals	0	1	*	0	0	*	0	1	*	*	0
Macrophytes	0	*	0	0	*	0	0	0	0	0	0
Periphyton	0	*	0	0	*	0	0	0	0	0	0
Phytoplankton	0	*	0	0	*	0	0	0	0	0	0
Zooplankton	0	*	0	0	*	0	0	0	0	0	0
Terrestrial Flora	0	0	*	*	0	*	*	*	*	*	*

Table C-6. Continued.

Physical/Chemical Alterations / Biota	Middle River												
	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	0	0	0		0	0	0	0	0
Mussels		0	*	0	0	0	0		0	0	0	0	0
Mammals		0	0	0	0	0	*		0	0	*	*	*
Birds		0	0	0	0	0	*		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	*	0	*
Amphibians		0	0	0	0	0	0		0	0	0	0	*
Macrophytes		0	*	0	0	0	0		0	0	0	0	*
Snails		0	*	0	0	0	0		0	0	0	0	0
Terrestrial Flora		0	0	*	0	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	0	*	0		0	0	0	0	0
Juveniles		0	*	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	0	0	*	0		0	0	0	0	0
Age/Growth		0	*	0	0	*	0		0	0	0	0	0
Feeding Habits		0	*	0	0	*	0		0	0	0	0	0
Distribution/Abundance		0	*	0	0	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	0		0	0	0	0	*
Management		0	*	0	*	*	0		*	*	*	*	*
Mussels		0	*	0	0	*	0		0	0	0	0	0
Benthos		0	*	0	0	*	0		0	0	0	0	0
Amphibians		1	0	0	1	0	0		1	1	0	0	1
Reptiles		1	0	0	0	1	0		1	1	*	*	0
Birds													
Waterfowl		0	0	0	0	0	*		0	0	*	*	0
Raptors		0	0	*	0	0	*		0	0	*	*	0
Other Birds		0	0	*	0	0	*		0	0	*	*	0
Mammals		0	0	*	0	0	*		0	0	*	*	0
Macrophytes		0	*	0	0	*	0		0	0	0	0	0
Periphyton		0	*	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	0	0	*	0		0	0	0	0	0
Zooplankton		0	*	0	0	*	0		0	0	0	0	0
Terrestrial Flora		0	0	*	*	0	*		*	*	*	*	*

Table C-7. Point Source Intakes and Discharges.

GREAT I Area

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	*	0	*	0	0		0	0	*	*	*
Birds		0	*	0	*	0	0		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	*	0		3	3	3	0	0
Juveniles		3	0	0	0	*	0		3	3	3	3	3
Adults													
Spawning/Reproduction		3	0	0	0	*	0		3	3	3	3	3
Age/Growth		3	0	0	0	*	0		3	3	3	3	3
Feeding Habits		3	0	0	0	*	0		1	1	1	1	1
Distribution/Abundance		3	0	0	0	*	0		3	3	3	3	3
Parasites/Diseases		3	0	0	0	*	*		0	0	0	0	0
Management		3	0	0	0	*	0		0	0	0	0	0
Mussels		5	0	0	0	*	0		5	5	5	3	3
Benthos		5	0	0	0	*	0		5	5	5	3	3
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	0	0	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		1	0	0	0	*	0		1	1	1	0	0
Periphyton		3	0	0	0	*	0		3	3	3	0	3
Phytoplankton		3	*	*	0	*	0		3	3	3	0	3
Zooplankton		3	*	*	0	*	0		3	3	0	0	3
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-7. Continued.

Biota \ Physical/Chemical Alterations (Pool 4)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	*	0	*	0	0		0	0	*	*	*
Birds		0	*	0	*	0	0		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		3	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		3	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	*	0		0	0	0	0	0
Parasites/Diseases		0	0	0	0	*	*		0	0	0	0	0
Management		3	0	0	0	*	0		0	0	0	0	0
Mussels		5	0	0	0	*	0		5	5	5	3	3
Benthos		5	0	0	0	*	0		5	5	5	3	3
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	0	0	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Periphyton		3	0	0	0	*	0		3	3	3	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-7. Continued.

Biota \ Physical/Chemical Alterations (GREAT II Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	*	0	*	0	0		0	0	*	*	*
Birds		0	*	0	*	0	0		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		3	0	0	0	*	0		0	0	0	0	0
Juveniles		3	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		3	0	0	0	*	0		0	0	0	0	0
Age/Growth		3	0	0	0	*	0		0	0	0	0	0
Feeding Habits		3	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		5	0	0	0	*	0		3	3	0	0	0
Parasites/Diseases		1	0	0	0	*	*		0	0	0	0	0
Management		3	0	0	0	*	0		0	0	0	0	0
Mussels		5	0	0	0	*	0		5	3	3	3	3
Benthos		5	0	0	0	*	0		5	5	5	5	5
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	1	0	0	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		1	0	0	0	*	0		1	0	0	0	0
Periphyton		5	0	0	0	*	0		5	3	3	0	3
Phytoplankton		5	*	*	0	*	0		5	3	3	0	3
Zooplankton		5	*	*	0	*	0		5	3	0	0	3
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-7. Continued.

Pool 19

Biota \ Physical/Chemical Alterations	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	*	0	*	0	0		0	0	*	*	*
Birds		0	*	0	*	0	0		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		3	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		3	0	0	0	*	0		0	0	0	0	0
Parasites/Diseases		0	0	0	0	*	*		0	0	0	0	*
Management		5	0	0	0	*	0		0	0	0	0	*
Mussels		5	0	0	0	*	0		5	3	3	3	3
Benthos		5	0	0	0	*	0		5	3	3	3	3
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Reptiles		0	0	0	0	0	0		0	0	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	1	0	0	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		1	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		0	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-7. Continued.

Biota \ Physical/Chemical Alterations (GREAT III Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	*	0	*	0	0		0	0	*	*	*
Birds		0	*	0	*	0	0		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		1	0	0	0	*	0		0	0	0	0	0
Parasites/Diseases		0	0	0	0	*	*		0	0	0	0	0
Management		3	0	0	0	*	0		0	0	0	0	0
Mussels		2	0	0	0	*	0		0	0	0	0	0
Benthos		3	0	0	0	*	0		3	0	0	0	0
Amphibians		3	0	0	0	0	0		3	3	1	0	1
Reptiles		3	0	0	0	0	0		3	3	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	0	0	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		1	0	0	0	*	0		0	0	0	0	0
Periphyton		1	0	0	0	*	0		0	0	0	0	0
Phytoplankton		1	*	*	0	*	0		0	0	0	0	0
Zooplankton		1	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-7. Continued.

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
	Middle River												
Threatened & Endangered Species													
Fish		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Mammals		0	*	0	*	0	0		0	0	*	*	*
Birds		0	*	0	*	0	0		0	0	*	*	*
Reptiles		0	0	0	0	0	0		0	0	0	0	0
Amphibians		0	0	0	0	0	0		0	0	0	0	0
Macrophytes		0	0	0	0	*	0		0	0	0	0	0
Snails		0	0	0	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	0	0	0	0
Indigenous Communities													
Fish													
Eggs & Larvae		0	0	0	0	*	0		0	0	0	0	0
Juveniles		0	0	0	0	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	0	0	0	*	0		0	0	0	0	0
Age/Growth		0	0	0	0	*	0		0	0	0	0	0
Feeding Habits		0	0	0	0	*	0		0	0	0	0	0
Distribution/Abundance		0	0	0	0	*	0		0	0	0	0	0
Parasites/Diseases		0	0	0	0	*	*		0	0	0	0	0
Management		0	0	0	0	*	0		0	0	0	0	0
Mussels		0	0	0	0	*	0		0	0	0	0	0
Benthos		3	0	0	0	*	0		3	0	3	0	0
Amphibians		3	0	0	0	0	0		3	3	1	0	1
Reptiles		3	0	0	0	0	0		3	3	*	*	0
Birds													
Waterfowl		0	0	0	0	0	0		0	0	0	0	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	*		0	0	*	*	0
Macrophytes		1	0	0	0	*	0		0	0	0	0	0
Periphyton		0	0	0	0	*	0		0	0	0	0	0
Phytoplankton		1	*	*	0	*	0		0	0	0	0	0
Zooplankton		0	*	*	0	*	0		0	0	0	0	0
Terrestrial Flora		*	*	0	*	0	*		*	*	*	*	*

Table C-8. Non Point Source Discharges.

GREAT I Area

Biota \ Physical/Chemical Alterations	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	*	*	0		0	0	0	0	0
Mussels		0	*	*	*	*	0		0	0	0	0	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Birds		0	*	*	*	0	0		0	0	*	*	0
Reptiles		0	*	*	*	0	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Snails		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	*	*	*	0		0	0	0	0	0
Juveniles		0	*	*	*	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	*	*	*	0		0	0	0	0	0
Age/Growth		1	*	*	*	*	0		0	0	0	0	0
Feeding Habits		0	*	*	*	*	0		0	0	0	0	0
Distribution/Abundance		1	*	*	*	*	0		1	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	*
Management		0	*	*	*	*	*		*	*	*	*	*
Mussels		0	*	*	*	*	0		0	0	0	0	0
Benthos		0	*	*	*	*	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	*	0
Reptiles		0	*	*	*	0	0		0	0	*	*	0
Birds													
Waterfowl		0	*	*	*	0	0		0	0	*	*	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Periphyton		0	*	*	*	*	0		0	0	0	0	0
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-8. Continued.

Biota \ Physical/Chemical Alterations (Pool 4)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	*	*	0		0	0	0	0	0
Mussels		0	*	*	*	*	0		0	0	0	0	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Birds		0	*	*	*	0	0		0	0	*	*	0
Reptiles		0	*	*	*	0	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Snails		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	*	*	*	0		0	0	0	0	0
Juveniles		0	*	*	*	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	*	*	*	0		0	0	0	0	0
Age/Growth		0	*	*	*	*	0		0	0	0	0	0
Feeding Habits		0	*	*	*	*	0		0	0	0	0	0
Distribution/Abundance		0	*	*	*	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	*
Management		0	*	*	*	*	*		*	*	*	*	*
Mussels		0	*	*	*	*	0		0	0	0	0	0
Benthos		0	*	*	*	*	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Reptiles		0	*	*	*	0	0		0	0	*	*	0
Birds													
Waterfowl		0	*	*	*	0	0		0	0	*	*	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Periphyton		0	*	*	*	*	0		0	0	0	0	0
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-8. Continued.

Physical/Chemical Alterations — GREAT II Area / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	*	*	0		0	0	0	0	0
Mussels		0	*	*	*	*	0		0	0	0	0	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Birds		0	*	*	*	0	0		0	0	*	*	0
Reptiles		0	*	*	*	0	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Snails		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	*	*	*	0		0	0	0	0	0
Juveniles		0	*	*	*	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		3	*	*	*	*	0		0	0	0	0	0
Age/Growth		0	*	*	*	*	0		0	0	0	0	0
Feeding Habits		0	*	*	*	*	0		0	0	0	0	0
Distribution/Abundance		3	*	*	*	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	*
Management		0	*	*	*	*	*		*	*	*	*	*
Mussels		0	*	*	*	*	0		0	0	0	0	0
Benthos		0	*	*	*	*	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Reptiles		0	*	*	*	0	0		0	0	*	*	0
Birds													
Waterfowl		0	*	*	*	0	0		0	0	*	*	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Periphyton		0	*	*	*	*	0		0	0	0	0	0
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-8. Continued.

Pool 19

Biota \ Physical/Chemical Alterations	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	*	*	0		0	0	0	0	0
Mussels		0	*	*	*	*	0		0	0	0	0	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Birds		0	*	*	*	0	0		0	0	*	*	0
Reptiles		0	*	*	*	0	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Snails		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	*	*	*	0		0	0	0	0	0
Juveniles		0	*	*	*	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	*	*	*	0		0	0	0	0	0
Age/Growth		0	*	*	*	*	0		0	0	0	0	0
Feeding Habits		0	*	*	*	*	0		0	0	0	0	0
Distribution/Abundance		1	*	*	*	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	*
Management		0	*	*	*	*	*		*	*	*	*	*
Mussels		0	*	*	*	*	0		0	0	0	0	0
Benthos		0	*	*	*	*	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Reptiles		0	*	*	*	0	0		0	0	*	*	0
Birds													
Waterfowl		0	*	*	*	0	0		0	0	*	*	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Periphyton		0	*	*	*	*	0		0	0	0	0	0
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-8. Continued.

Physical/Chemical Alterations / Biota	GREAT III Area												
	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	*	*	0		0	0	0	0	0
Mussels		0	*	*	*	*	0		0	0	0	0	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Birds		0	*	*	*	0	0		0	0	*	*	0
Reptiles		0	*	*	*	0	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Snails		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	*	*	*	0		0	0	0	0	0
Juveniles		0	*	*	*	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	*	*	*	0		0	0	0	0	0
Age/Growth		0	*	*	*	*	0		0	0	0	0	0
Feeding Habits		0	*	*	*	*	0		0	0	0	0	0
Distribution/Abundance		1	*	*	*	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	*
Management		0	*	*	*	*	*		*	*	*	*	*
Mussels		0	*	*	*	*	0		0	0	0	0	0
Benthos		0	*	*	*	*	0		0	0	0	0	0
Amphibians		1	*	*	*	0	0		0	0	0	0	0
Reptiles		1	*	*	*	0	0		0	0	*	*	0
Birds													
Waterfowl		0	*	*	*	0	0		0	0	*	*	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Periphyton		0	*	*	*	*	0		0	0	0	0	0
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-8. Continued.

Biota \ Physical/Chemical Alterations	Middle River: Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	*	*	*	0		0	0	0	0	0
Mussels		0	*	*	*	*	0		0	0	0	0	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Birds		0	*	*	*	0	0		0	0	*	*	0
Reptiles		0	*	*	*	0	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Snails		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	*	*	*	0		0	0	0	0	0
Juveniles		0	*	*	*	*	0		0	0	0	0	0
Adults													
Spawning/Reproduction		0	*	*	*	*	0		0	0	0	0	0
Age/Growth		0	*	*	*	*	0		0	0	0	0	0
Feeding Habits		0	*	*	*	*	0		0	0	0	0	0
Distribution/Abundance		0	*	*	*	*	0		0	0	0	0	0
Parasites/Diseases		0	*	*	*	*	*		0	0	0	0	*
Management		0	*	*	*	*	*		*	*	*	*	*
Mussels		0	*	*	*	*	0		0	0	0	0	0
Benthos		0	*	*	*	*	0		0	0	0	0	0
Amphibians		0	*	*	*	0	0		0	0	0	0	0
Reptiles		0	*	*	*	0	0		0	0	*	*	0
Birds													
Waterfowl		0	*	*	*	0	0		0	0	*	*	0
Raptors		0	*	*	*	0	*		0	0	*	*	0
Other Birds		0	*	*	*	0	*		0	0	*	*	0
Mammals		0	*	*	*	0	0		0	0	*	*	0
Macrophytes		0	*	*	*	*	0		0	0	0	0	0
Periphyton		0	*	*	*	*	0		0	0	0	0	0
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	0	0
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-9. Commercial Navigation.

Physical/Chemical Alterations → Biota ↓ (GREAT I Area)	Habitat Alterations						Water Quality Alterations				
	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species											
Fish	0	*	0	*	*	0	0	0	0	*	*
Mussels	0	*	0	*	*	0	0	0	0	*	*
Mammals	0	*	0	*	0	*	0	0	*	*	*
Birds	0	*	0	*	0	*	0	0	*	*	*
Reptiles	0	*	0	*	0	0	0	0	*	*	*
Amphibians	0	*	0	*	0	0	0	0	0	*	*
Macrophytes	0	*	0	*	*	0	0	0	0	0	*
Snails	0	*	0	*	*	0	0	0	0	*	
Terrestrial Flora	*	*	*	*	0	*	*	*	*	*	*
Indigenous Communities											
Fish											
Eggs & Larvae	3	*	0	*	*	0	0	0	0	*	*
Juveniles	3	*	0	*	*	0	0	0	0	*	*
Adults											
Spawning/Reproduction	0	*	0	*	*	0	0	0	0	*	*
Age/Growth	0	*	*	*	*	0	0	0	0	*	*
Feeding Habits	0	*	*	*	*	0	0	0	0	*	*
Distribution/Abundance	3	*	*	*	*	0	3	1	0	*	*
Parasites/Diseases	0	*	*	*	*	*	*	*	*	*	*
Management	3	*	*	*	*	0	*	*	0	*	*
Mussels	0	*	0	*	*	0	0	0	0	*	*
Benthos	0	*	0	*	*	0	0	0	0	*	*
Amphibians	0	*	0	*	0	0	0	0	0	*	*
Reptiles	0	*	0	*	0	0	0	0	*	*	*
Birds											
Waterfowl	0	*	0	*	0	0	0	0	*	*	*
Raptors	0	*	0	*	0	*	0	0	*	*	*
Other Birds	0	*	0	*	0	*	0	0	*	*	*
Mammals	0	*	0	*	0	*	0	0	*	*	*
Macrophytes	0	*	0	*	*	0	0	0	0	*	*
Periphyton	0	*	0	*	*	0	0	0	0	*	*
Phytoplankton	0	*	*	*	*	0	0	0	0	0	0
Zooplankton	0	*	*	*	*	0	0	0	0	*	*
Terrestrial Flora	*	*	*	*	0	*	*	*	*	*	*

Table C-9. Continued.

Physical/Chemical Alterations / Biota	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
	Pool 4												
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Birds		0	*	0	*	0	*		0	0	*	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	0	*
Snails		0	*	0	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		1	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		1	*	*	*	*	0		1	1	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		1	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	0	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-9. Continued.

Physical/Chemical Alterations / Biota (GREAT II Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Birds		0	*	0	*	0	*		0	0	*	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	0	*
Snails		0	*	0	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		3	*	0	*	*	0		0	0	0	*	*
Juveniles		3	*	0	*	*	0		1	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		3	*	*	*	*	0		3	3	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		3	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	0	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-9. Continued.

Biota \ Physical/Chemical Alterations (Pool 19)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Birds		0	*	0	*	0	*		0	0	*	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	0	*
Snails		0	*	0	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		0	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		1	*	*	*	*	0		1	1	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		1	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	0	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-9. Continued.

Physical/Chemical Alterations / Biota	GREAT III Area												
	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Birds		0	*	0	*	0	*		0	0	*	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	0	*
Snails		0	*	0	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		0	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		0	*	*	*	*	0		0	0	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		1	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	0	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-9. Continued.

Biota \ Physical/Chemical Alterations (Middle River)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Birds		0	*	0	*	0	*		0	0	*	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	0	*
Snails		0	*	0	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		0	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distriuution/Abundance		0	*	*	*	*	0		0	0	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		0	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	0	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-10. Recreational Navigation.

Biota \ Physical/Chemical Alterations (GREAT I Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	*	*	*	*
Birds		0	*	0	*	0	*		0	*	*	*	*
Reptiles		0	*	0	*	0	0		0	*	*	*	*
Amphibians		0	*	0	*	0	0		0	*	0	*	*
Macrophytes		0	*	0	*	*	0		0	*	0	0	*
Snails		0	*	0	*	*	0		0	*	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		1	*	0	*	*	0		0	0	0	*	*
Juveniles		1	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		3	*	*	*	*	0		3	1	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		3	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	*		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	*	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-10. Continued.

Physical/Chemical Alterations / Biota	Pool 4												
	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	*	*	*	*
Birds		0	*	0	*	0	*		0	*	*	*	*
Reptiles		0	*	0	*	0	0		0	*	*	*	*
Amphibians		0	*	0	*	0	0		0	*	0	*	*
Macrophytes		0	*	0	*	*	0		0	*	0	0	*
Snails		0	*	0	*	*	0		0	*	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		0	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		1	*	*	*	*	0		1	1	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		1	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	*	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-10. Continued.

Biota \ Physical/Chemical Alterations (GREAT II Area)	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	*	*	*	*
Birds		0	*	0	*	0	*		0	*	*	*	*
Reptiles		0	*	0	*	0	0		0	*	*	*	*
Amphibians		0	*	0	*	0	0		0	*	0	*	*
Macrophytes		0	*	0	*	*	0		0	*	0	0	*
Snails		0	*	0	*	*	0		0	*	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		3	*	0	*	*	0		0	0	0	*	*
Juveniles		3	*	0	*	*	0		1	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		3	*	*	*	*	0		3	1	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		3	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	*	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	0	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-10. Continued.

Physical/Chemical Alterations / Biota	Pool 19: Habitat Alterations						Water Quality Alterations				
	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species											
Fish	0	*	0	*	*	0	0	0	0	*	*
Mussels	0	*	0	*	*	0	0	0	0	*	*
Mammals	0	*	0	*	0	*	0	*	*	*	*
Birds	0	*	0	*	0	*	0	*	*	*	*
Reptiles	0	*	0	*	0	0	0	*	*	*	*
Amphibians	0	*	0	*	0	0	0	*	0	*	*
Macrophytes	0	*	0	*	*	0	0	*	0	0	*
Snails	0	*	0	*	*	0	0	*	0	*	*
Terrestrial Flora	*	*	*	*	0	*	*	*	*	*	*
Indigenous Communities											
Fish											
Eggs & Larvae	0	*	0	*	*	0	0	0	0	*	*
Juveniles	0	*	0	*	*	0	0	0	0	*	*
Adults											
Spawning/Reproduction	0	*	0	*	*	0	0	0	0	*	*
Age/Growth	0	*	*	*	*	0	0	0	0	*	*
Feeding Habits	0	*	*	*	*	0	0	0	0	*	*
Distribution/Abundance	1	*	*	*	*	0	0	0	0	*	*
Parasites/Diseases	0	*	*	*	*	*	*	*	*	*	*
Management	1	*	*	*	*	0	*	*	0	*	*
Mussels	0	*	0	*	*	0	0	0	0	*	*
Benthos	0	*	0	*	*	0	0	0	0	*	*
Amphibians	0	*	0	*	0	0	0	0	0	*	*
Reptiles	0	*	0	*	0	0	0	0	*	*	*
Birds											
Waterfowl	0	*	0	*	0	0	0	0	*	*	*
Raptors	0	*	0	*	0	*	0	0	*	*	*
Other Birds	0	*	0	*	0	*	0	0	*	*	*
Mammals	0	*	0	*	0	*	0	0	*	*	*
Macrophytes	0	*	0	*	*	0	0	0	0	*	*
Periphyton	0	*	0	*	*	0	0	0	0	*	*
Phytoplankton	0	*	*	*	*	0	0	0	0	0	0
Zooplankton	0	*	*	*	*	0	0	*	0	*	*
Terrestrial Flora	*	*	*	*	0	*	*	*	*	*	*

Table C-10. Continued.

GREAT III Area

Biota \ Physical/Chemical Alterations	Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	0	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Mammals		0	*	0	*	0	*		0	*	*	*	*
Birds		0	*	0	*	0	*		0	*	*	*	*
Reptiles		0	*	0	*	0	0		0	*	*	*	*
Amphibians		0	*	0	*	0	0		0	*	0	*	*
Macrophytes		0	*	0	*	*	0		0	*	0	0	*
Snails		0	*	0	*	*	0		0	*	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		0	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		0	*	*	*	*	0		0	0	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		0	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	*	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	*	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

Table C-10. Continued.

Biota \ Physical/Chemical Alterations	Middle River: Habitat Alterations	Sedimentation & Resuspension	Physical Removal & Disruptions	Burial	Dessication	Inundation	Velocity/Flow	Water Quality Alterations	Turbidity	Toxic Substances	Oxygen Related	Nutrient Related	pH Related
Threatened & Endangered Species													
Fish		0	*	0	*	*	0		0	*	0	*	*
Mussels		0	*	0	*	*	0		0	*	0	*	*
Mammals		0	*	0	*	0	*		0	*	*	*	*
Birds		0	*	0	*	0	*		0	*	*	*	*
Reptiles		0	*	0	*	0	0		0	*	*	*	*
Amphibians		0	*	0	*	0	0		0	*	0	*	*
Macrophytes		0	*	0	*	*	0		0	*	0	0	*
Snails		0	*	0	*	*	0		0	*	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*
Indigenous Communities													
Fish													
Eggs & Larvae		0	*	0	*	*	0		0	0	0	*	*
Juveniles		0	*	0	*	*	0		0	0	0	*	*
Adults													
Spawning/Reproduction		0	*	0	*	*	0		0	0	0	*	*
Age/Growth		0	*	*	*	*	0		0	0	0	*	*
Feeding Habits		0	*	*	*	*	0		0	0	0	*	*
Distribution/Abundance		0	*	*	*	*	0		0	0	0	*	*
Parasites/Diseases		0	*	*	*	*	*		*	*	*	*	*
Management		0	*	*	*	*	0		*	*	0	*	*
Mussels		0	*	0	*	*	0		0	0	0	*	*
Benthos		0	*	0	*	*	0		0	0	0	*	*
Amphibians		0	*	0	*	0	0		0	0	0	*	*
Reptiles		0	*	0	*	0	0		0	0	0	*	*
Birds													
Waterfowl		0	*	0	*	0	0		0	0	*	*	*
Raptors		0	*	0	*	0	*		0	0	*	*	*
Other Birds		0	*	0	*	0	*		0	0	*	*	*
Mammals		0	*	0	*	0	*		0	0	0	*	*
Macrophytes		0	*	0	*	*	0		0	0	0	*	*
Periphyton		0	*	0	*	*	0		0	0	*	*	*
Phytoplankton		0	*	*	*	*	0		0	0	0	0	0
Zooplankton		0	*	*	*	*	0		0	0	0	*	*
Terrestrial Flora		*	*	*	*	0	*		*	*	*	*	*

DATE
ILMED
-8